JUNE
1955

SCHOOL OF ENGINEERING
PRINCETON UNIVERSITY
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MECHANICAL ENGINEERING

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ASME Diamond Jubilee Semi-Annual Meeting ◆ Boston, Mass. ◆ June 19–23, 1955

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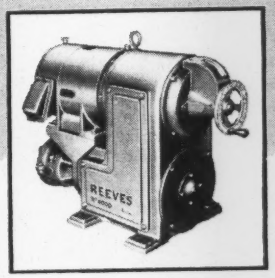

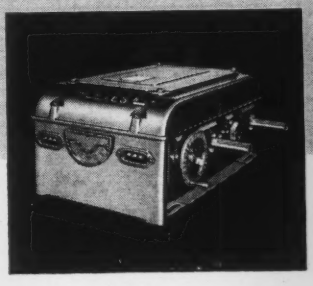

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Vapor Pressure Bellows Devices for Remote Control of Temperature

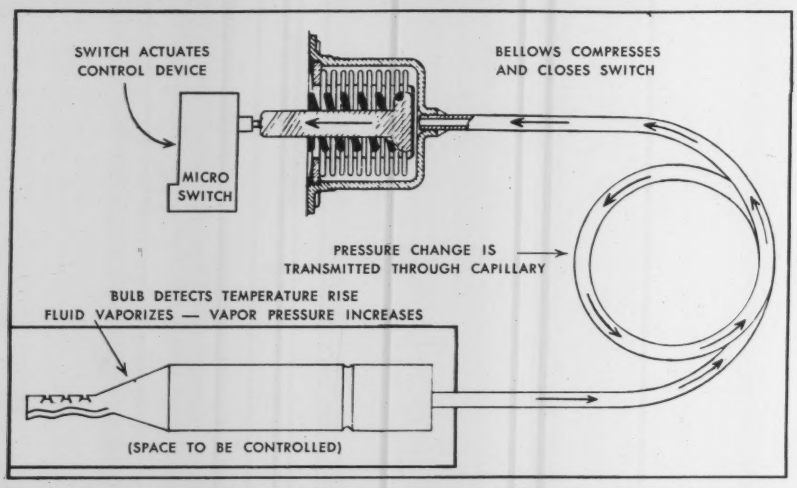
SWITCH ACTUATES CONTROL DEVICE
BELLOWS COMPRESSES AND CLOSES SWITCH
MICRO SWITCH
PRESSURE CHANGE IS TRANSMITTED THROUGH CAPILLARY
BULB DETECTS TEMPERATURE RISE
FLUID VAPORIZES — VAPOR PRESSURE INCREASES
(SPACE TO BE CONTROLLED)

Figure 1. Vapor pressure bellows assemblies provide remote temperature control over a temperature range from about −40F to a maximum of 500F, depending on the vapor pressure of the filling medium at the maximum temperature encountered. They offer the advantage of high sensitivity and relatively long bellows stroke. This principle may be applied using increase or decrease of the vapor pressure to transmit the force to actuate a control mechanism.

ADVANTAGES OF VAPOR PRESSURE CONTROLS

Vapor pressure bellows assemblies offer a number of advantages in temperature control applications. They are highly sensitive and provide very close temperature control. They are positive-acting, simple in operation and easy to install. They can be made "fail-safe" to protect the equipment to which they are applied. When spring loaded, vapor pressure assemblies can be adjusted within very close limits. Bellows stroke is relatively long, making it easy to actuate switches or valves without elaborate linkage. They can be used for temperatures as low as −40F or as high as 500F and not affected by ambient temperatures outside of the chamber to be controlled. As a result, vapor pressure bellows assemblies are widely used as temperature controls for refrigerators, ovens, appliances, hot water storage tanks, processing equipment, wax pots, acid baths and numerous specialized industrial applications.

Proved in use. Vapor pressure bellows systems have long been used as temperature controls. Hence, a large body of performance and design data has been accumulated. This data assures accurate prediction of performance of a vapor pressure assembly, given the conditions under which the system will operate. And, since the design considerations are well known, it is usually simple to design a vapor pressure bellows assembly that will meet service requirements satisfactorily. The Clifford Manufacturing Company has a broad range of standard thermostatic assemblies engineered for quality, economy and reliable operation. These can be furnished to meet a wide variety of temperature control applications or readily adapted in design to meet special requirements. Important savings can be achieved by utilizing a standard design. A sketch showing controlling factors and dimensions for your application will enable Clifford to advise you how a standard design will meet your requirements.

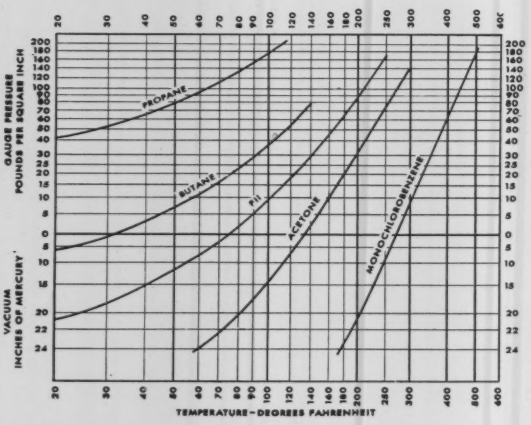

Figure 2. Vapor pressure-temperature curves for a few of the more common fluids used in vapor pressure bellows assemblies.

Operating principle (Fig. 1). When a confined liquid is heated, a vapor pressure is generated in the space above it. Vapor pressure as a function of temperature varies according to definite laws and so may be predicted accurately (see curves, Fig. 2).

Vapor pressure increases in an exponential curve. Butane, for example, from 30F to 40F changes pressure only 3 psi, but from 90F to 100F changes 9 psi. Therefore, a switch that operates with a .010 movement would have ⅓ the *temperature* differential at the higher end of the curve than a control operating at the low end of the curve.

The thermal fluid is stored in a temperature sensing bulb which is placed in the space to be controlled. The bulb is connected to a bellows cup assembly by a capillary tube. As the temperature of the bulb rises, vapor pressure in the bulb increases and is transmitted through the capillary to the cup. The force is exerted against the outside of the bellows, compressing it and moving the attached rod to actuate a switch or valve. A spring is usually incorporated as an adjusting means to provide an accurate setting of control temperature.

DESIGN CONSIDERATIONS

In the design of vapor-pressure systems, several factors must be considered: temperature range to be controlled, required sensitivity and the ambient temperature limits encountered. These requirements must be met by the right combination of bulb and bellows design and the thermal "fill" of the system.

Different combinations of factors are required if the controlled temperature is below, above, or *both* below *and* above the ambient temperature at the bellows. **Controls — bulb temperature lower than bellows.** A control designed to operate at zero F, for example, must be charged with a thermal liquid having an active vapor pressure at that point, although the boiling point may be either above or below zero F. Methyl chloride (see Fig. 2) would be a logical filling medium for this application; it has a boiling point just under minus 10F and a vapor pressure of 3 to 4 psig at zero F. When used in refrigeration equipment, it functions satisfactorily, but since it has a vapor pressure of 150 psi at 120F, it would produce excessive pressure when subjected to high temperatures such as during shipment or storage of the unit. To design the assembly to withstand the overpressure would unnecessarily reduce the sensitivity of the control.

This is easily avoided in Clifford units through a calculated limited filling of the system. A volume of volatile liquid is selected so that it will be completely

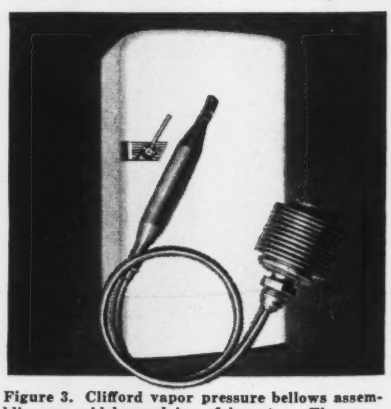

Figure 3. Clifford vapor pressure bellows assemblies are widely used in refrigerators. They provide positive action for the close temperature control essential to modern refrigeration.

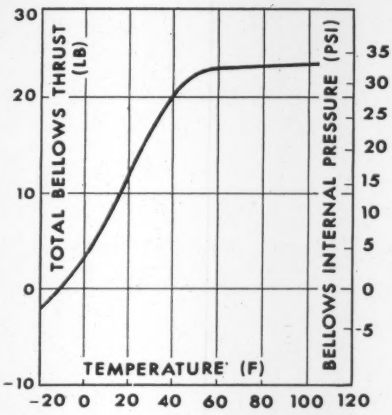

Figure 4. Temperature vs. thrust curve for a 1¼" bellows with limited fill of methyl chloride. Full vaporization is complete about 50F. Only negligible gaseous expansion occurs above that point.

vaporized at a temperature just above the maximum desired control temperature. Beyond that point, only gaseous expansion takes place. Figure 3 shows the limited fill curve for a typical filling medium used in refrigerator temperature controls. Standard Clifford vapor pressure assemblies already engineered are obtainable for control of temperatures as low as −40F.

Ambient temperature has no significant effect on low temperature controls, because the volatile liquid is wholly contained in the bulb, which is usually quite small and located in the chamber to be controlled.

The pressure throughout the entire thermostatic assembly is always governed by the bulb temperature.

Controls—bulb temperature higher than bellows. For controls designed to operate at temperatures higher than the ambient temperature at the bellows, the assembly is almost completely filled with liquid. The vapor pressure is generated at the hottest point (the bulb) and transmitted to the bellows cup by the hydraulic action of the filling medium. The bulb is designed to trap the vapor within it, so that only *liquid* is forced out of the bulb and into the capillary and bellows cup. Over-temperature protection can be provided by limiting bulb size. Controls of this type are unaffected by ambient temperature. *The vapor pressure in the system is always a function of bulb temperature.*

Universal service. For control of temperatures *both* below *and* above the ambient temperature at the bellows, universal systems can be designed that draw on the principles of operation of both the low and the high temperature types just described. The bellows cup, capillary and bulb assembly is charged with a definite, precisely measured volume of the thermal liquid. When the capillary and bellows cup are *completely filled* with the thermal liquid, there must still be enough liquid left in the bulb to generate the necessary vapor pressure.

When the bellows and capillary temperatures go above the operating temperatures at the bulb, the liquid in the bellows and capillary vaporizes, expands into the bulb and condenses. The bellows cup is thus filled with a superheated gas at the same pressure as the vapor pressure generated by the volatile liquid in the bulb. A transition point is reached when the temperature of the bellows and capillary just equals that of the bulb. As the temperature of the bellows and capillary drops *below* that of the bulb, the liquid in the bulb rapidly vaporizes and condenses in the bellows and capillary until they are completely filled. Bulb design provides for some liquid to remain in the bulb. Further temperature increases bring about an increase in vapor pressure which is transmitted hydraulically through the capillary to the bellows cup.

Under any of the above conditions the temperature at the bulb always controls the operation of the system. The universal type control satisfies requirements that can be filled by neither the low-temperature nor high-temperature vapor-pressure types alone.

Dual Fill - Universal service can be obtained by a "dual fill" system. The unit is filled with controlled amounts of two insoluble liquids. Temperature changes are sensed by one liquid and the resulting vapor pressure changes are transmitted hydraulically through the second liquid to the bellows cup. This type of unit can be designed to have the "knock off" characteristics of the limited-fill unit (see Fig. 3).

"Fail-Safe" Design. If a liquid is chosen with a boiling point *above* the control point, the system operates under vacuum up through the control point. Vacuum should usually be limited to about 15 inches of mercury. Vacuum operation provides a "fail safe" feature in such applications as automobile thermostats. In the event that leakage occurs in the bellows or elsewhere in a closed system, the thermostat locks "open" and coolant continues to flow through the system. When controlling a heating medium, the control locks "closed" to shut off the source of the supply of heat.

Thrust. In vapor pressure assemblies, the thrust of the bellows at any temperature is definitely fixed by the vapor pressure of the filling medium and cannot be changed. Similarly, thrust differential between any two temperatures is fixed by the filling medium. Therefore, in the mechanical design of switch or valve mechanisms, friction should be minimized and maintained at a constant value.

Adjustment is commonly achieved by means of a spring and adjusting screw arrangement. The spring can control the operating temperature, the operating differential and the range over which the control temperature can be adjusted. The adjusting spring mechanism must be interrelated with the bellows cup assembly to achieve the desired operating characteristics.

Barometric compensation. For systems requiring extreme accuracy, it is sometimes desirable to compensate for barometric changes. Such correction is provided simply and accurately by a Clifford differential pressure unit (see Fig. 6). The vapor pressure is transmitted to the outside surface of the large bellows. The other side of the bellows is evacuated. The barometric changes then act on the areas of the smaller bellows, producing a null effect.

Clifford Manufacturing Company will consult with you regarding a thermostatic assembly that will meet your requirements. If you have an immediate problem, send a sketch showing controlling factors of your application and we will recommend a suitable control.

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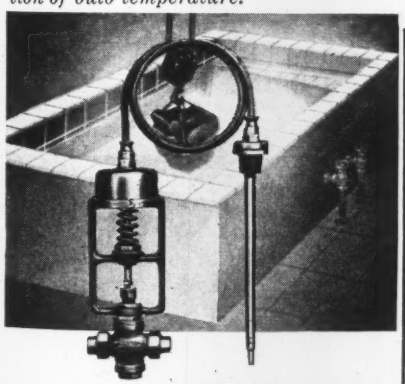

Figure 5. Temperature regulators for water heating or cooling tanks, steam cookers, acid baths, glue heaters, bottle washers, tempering baths and other heating specialties used Clifford vapor pressure bellows assemblies as actuating elements.

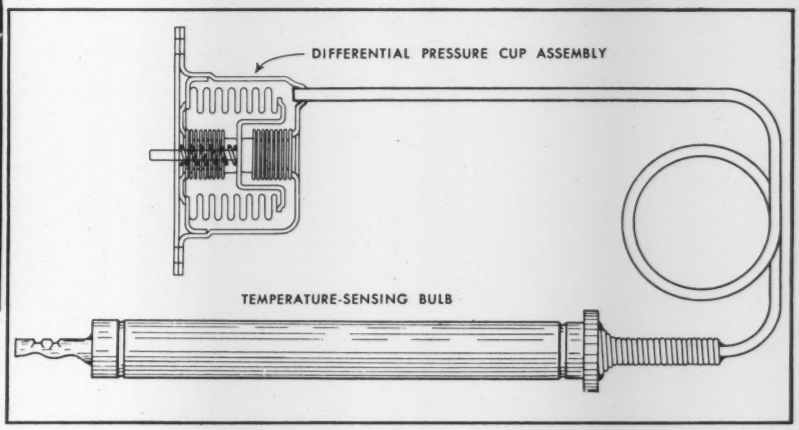

Figure 6. Vapor pressure bellows assembly with automatic barometric compensation.

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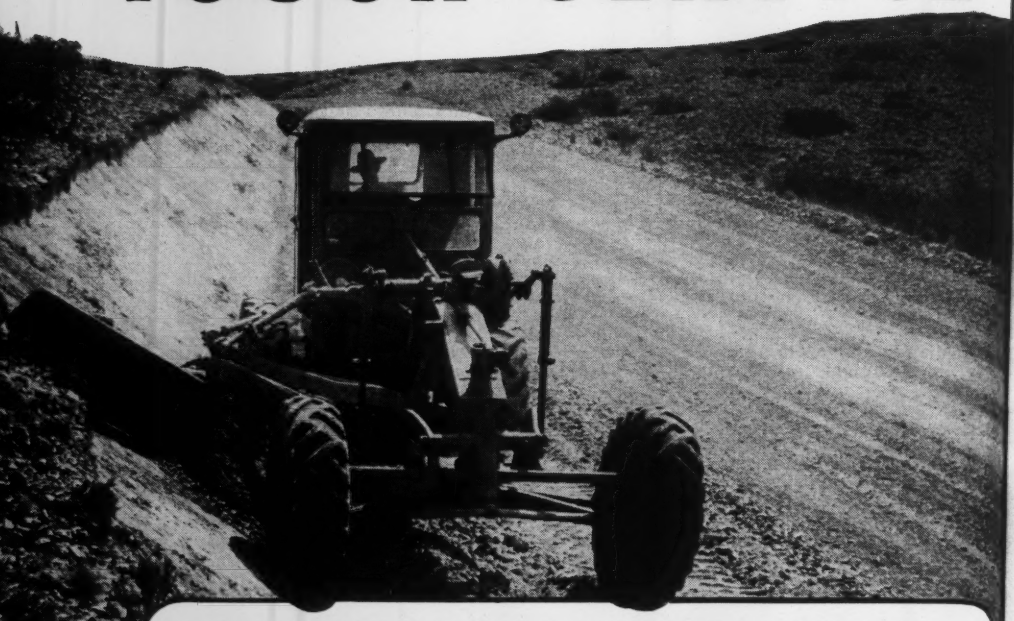

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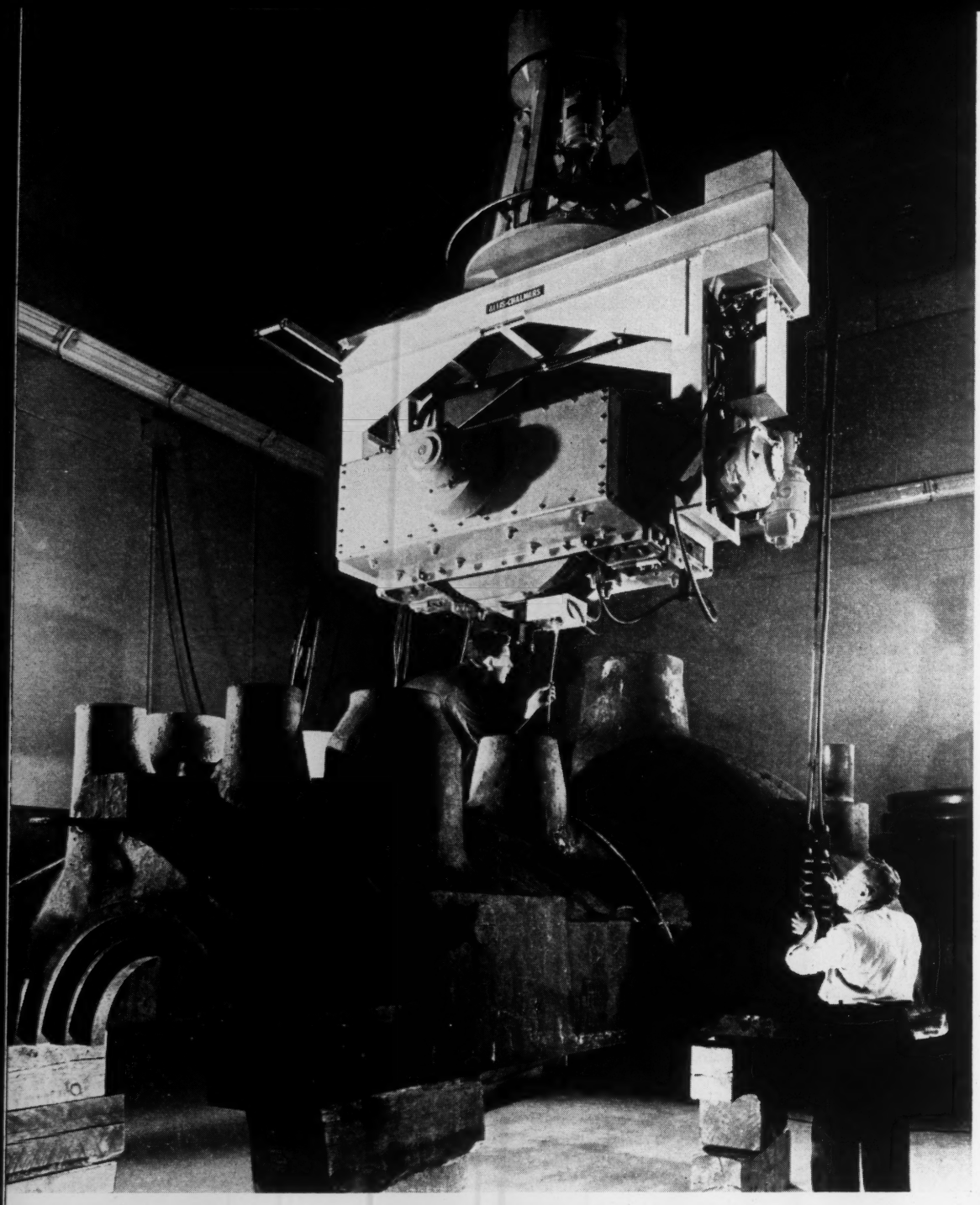

A 22,000,000-volt industrial betatron . . .

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Editorial

MECHANICAL ENGINEERING

June, 1955, Vol. 77, No. 6 ◆ George A. Stetson, *Editor*

What Engineers Have Done . . .

ANY appraisal of the contributions of mechanical engineering to the material standards of living of the free world today must include the high rate of the production of goods which has been achieved and the effects it has had on the well-being and happiness of our people.

This theme is so familiar and has been developed so many times that engineers are likely to take it for granted and their critics to accuse them of a gross materialism.

The industrial economy of the western world, which began about two hundred years ago, is today in process of expansion in other parts of the world. If the immediate consequences appear to be disruptive, then we must remind ourselves that such has always been the experience of the human race. Few of us would be willing to exchange today for any one of the "golden ages" of the past, except perhaps in some of those privileged roles practically none of us would have had the good fortune to play. The promise of the future is much more attractive than the actualities of the past.

What great contributions has engineering made to material progress?

Consider first machinery. Man has always sought to improve his skills, reduce muscle labor, and increase the amount and quality of his product by means of tools and machinery. With relatively few exceptions ingenious artisans themselves developed these aids. It was only when machines, made possible by new sources of power to drive them and of other machines to make them, proliferated that engineering became essential.

But no matter how ingenious and useful a machine may be, its production is limited by the power available to drive it. Wind and water power can be utilized only in certain places and under certain conditions. But with the introduction of the steam engine a more dependable source of power was introduced. The steam engine can be operated almost anywhere and can be used for land and sea transportation as well as a source of power at a fixed site. It gave tremendous impetus to the factory system. Ultimately, it destroyed the cottage industries and separated many craftsmen from ownership of the tools and machines of their trades. Later, combined with electricity and supplemented by the internal-combustion engine, it vastly multiplied the power available to every workman and the amount of production per capita, not only in the manufacturing plant, but on the farm, in transportation and communication, and in the home as well. Cheap power, available anywhere, at any time, for any purpose, has been one of the great contributions of engineering to modern life and abundant production.

Abundant production demands mass markets, and mass markets demand mass production. Mass production demands more than machines, machine tools to make them, and power to drive them. It demands manufacturing methods as well—duplicate manufacture of interchangeable parts, automatic machinery, jigs and fixtures, gages and inspection methods, higher quality of product and precision, standardization, assembly methods, integration of thousands of operations into a plant which receives raw material and turns out a product of acceptable quality at a minimum cost. Not only in the design of product and plants and machinery to manufacture it but in the techniques of production do engineers contribute to the high rate of production which the western world enjoys today. Under the stimulation of the benefits to be derived, all of these areas of development continue to expand rapidly today.

Nor in considering the contributions of engineers must we forget to include what they have done to apply the discoveries of natural science and the economic, life, and social sciences.

. . . And Can Do

There remain among these broad categories of engineering contributions those made in the field of management. The American Society of Mechanical Engineers is justly proud of the great number of significant contributions made by its members to this important influence in man's struggle to increase his productivity and of the growing number of its members who are engaged in the field of management. In so far as engineering is concerned, the greatest advancement of the welfare of mankind that engineers can provide is to be made in this field. With the present upsurge of developments in management an era is dawning which will be as significant as that initiated by Taylor, Gantt, or the Gilbreths—one which will continue the American tradition of technical improvements in design of machines and manufacturing methods, and will advance our way of life, opportunities for personal satisfaction and growth, and the individual liberties of the men and women who produce and consume the goods we all enjoy.

Dispersal of Industry in the Atomic Age

Sound defensive measures in case of atomic attack call for efficient dispersal of industries and people

By Lieut. Gen. Leslie R. Groves, USA (Ret.)

Vice-President,
Remington Rand, Inc.,
Stamford, Conn.

Since the dawn of history the world has always been changing. To us, however, our world of today seems to be changing more rapidly, and perhaps more decisively, than at any previous period of history since that recorded in the first verse of the first chapter of the first book of the Bible—Genesis.

First—there is the great impact of modern mass production, the interchangeable part with the assembly lines it makes possible, and the continuous processing of chemicals instead of the former batch system.

Second—and foremost, at least in its drama—there is the splitting of the atom and the great developments that are continuing to flow from that splitting.

Third—and of almost equal importance—there are the changes in technology and the control of technological processes, possibly most dramatically evidenced in the field of electronics. This aspect of our "changing world" is often referred to as the "Age of Automation."

THE problems that are confronting the world today were created as a result of the advances in the technical and scientific knowledge of modern man. We all share the responsibility for reaching the best possible solution to these problems and for making the best possible use of the developments resulting from these advances.

What are some of these problems?

First, there are no longer any sections in the world so isolated that their problems do not affect the rest of the world. In consequence, little wars are a thing of the past. We can no longer be certain that a small war can be localized, that it will not even develop into a major war or even a global war.

Second, we no longer have wars solely between military forces. In World War II there were few people in Europe or in the Western Pacific who could avoid the direct effects of war. If World War III comes, there will be few throughout the world who can do so.

And third—and perhaps the most far-reaching development of all—we have created the technical means to destroy civilization.

The responsibility which we now face is therefore a grave and a serious one.

Engineers' Responsibility

As engineers, to what extent must we assume this responsibility—and how will we be able to discharge it?

In our civilization the engineer plays a dual, even a threefold, role: He must be a pioneer and a builder, and at the same time, and like the military man, he must be the adviser to the average citizen who cannot understand many of the problems with which we are faced.

He must be a man with his feet on the ground and his eyes turned toward the skies.

He must be able to foresee the future while he is making use of the present.

He must have technical knowledge, professional skill, and imagination.

Perhaps the most significant question we must ask ourselves today is: What are our moral obligations in the development of these new things that are changing our world—such as atomic energy and automation?

Are we creating tools that may destroy civilization as we know it?

Use of Nuclear Weapons

We may at any time be confronted with the even more specific basic question with reference to the atomic and hydrogen bombs: Should they be used in case of war?

Pope Pius raised this very question in his solemn Easter appeal, in which he called for a ban on atomic, biological, and chemical weapons of war "before man destroys life on this earth."

No one can fail to recognize that the Pope was animated by the most lofty ideals in making this universal appeal.

The question of morality in the use of nuclear weapons can best be answered by asking other questions: Is it worse to kill an enemy with an atomic bomb than it is

Based on an address delivered at the Banquet during the Diamond Jubilee Spring Meeting, Baltimore, Md., April 17–22, 1955, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

with a bayonet, with a rifle bullet, or with a projectile from a battleship? What will be the effect on the American people and the world if such a ban were put into effect? Would a nation respect such a ban, when to do so would mean defeat instead of victory?"

If such an agreement were to be made, it is difficult to see how the future complete domination of Europe and Asia by Russia could be avoided. And, if it had been in effect in 1945, we could have seen this happen already or we could have had another world holocaust, or possibly both could have occurred.

Our major objective must remain as always to prevent a war but if it comes we must wage it successfully and achieve victory at the lowest possible price. The only logical way to prevent a war is to make it suicidal for anyone to start one.

If Russia knows she cannot dominate Europe and Asia—that she would be destroyed if she tried—we could be free from the threat of war—even of a cold war.

The H-bomb is not different from the A-bomb, except in degree. It is just more destructive.

On the other hand, if a cobalt bomb is developed, produced, and used as effectively as pure theory might indicate, then an entirely new philosophy of war will be introduced, for in such a case great areas—even countries as large as ours or Russia—can be made uninhabitable for years with a single large attack.

This new philosophy of nuclear warfare must concern us, because it would present what we have only talked about in the past—"total war." The A-bomb and H-bomb have brought war potentially to the doorstep of everyone living today. The perils of war would fall alike upon the soldier and upon the civilian.

There would be no noncombatants in such a war, for the enemy would attempt to destroy our technical and industrial capacity and our workers, as well as our men in uniform.

Effective Retaliation a Must

Let us remember always that no enemy will attack us if he feels that the price he will pay as a result will be too great. He must be made to realize that if he attacks us, we will retaliate, and the cost to him in cities and factories destroyed and people killed will be too terrible for him to risk the first step. He must also be made to understand that we are dispersing our industries and otherwise improving our defenses so that the damage he can do us by an atomic attack will not be overwhelmingly decisive.

There is no doubt that Russia can deliver an atomic attack—by air or by water, or through clandestine introduction of weapons into our homeland before a war is begun.

Atomic weapons can be brought within range of our coastline, or exploded in our harbors. They can be launched from submarines, or be placed in key spots around the country.

Dispersal of Industry Necessary

Our defense against this kind of attack is more difficult than against open assault of the type we have witnessed in previous wars—but it is no less necessary. One of the important things we can do is disperse our industries and our centers of population so that there will be no key points of vulnerability.

It became evident to any intelligent person on August 6, 1945, when we exploded the first atom bomb over Hiroshima—that we must disperse our industry; that if we did not, we could in time be destroyed with a single attack.

There are few important military items which are not at some time in the course of the manufacture of the completed item produced in large factories. Our goal should be to make it impossible for a single enemy bomb to destroy more than ten per cent of the production of a single military item. We can do this, but not if we continue to build and enlarge enormous production plants and continue to concentrate them in and near large cities.

At the same time Russia is just as vulnerable as we are, and possibly more so.

We are constantly hearing that lack of information on atomic affairs is preventing us from making intelligent decisions.

All the information that is needed and has been needed for intelligent leaders can be expressed in a few sentences and the facts contained in these few sentences have been known to all ever since 1945.

These facts are as follows:

Atomic and hydrogen bombs can be produced. They can be transported and delivered on a target by an airplane or a rocket.

They can be brought into harbors by surface vessels or fired from submarines. Their parts can be introduced into our country surreptitiously and then assembled into bombs in this country.

A single bomb can destroy square miles of a city and can kill or injure people by the tens of thousands.

Our own stock of bombs is adequate and is constantly increasing.

The only sound defensive measures are:

To avoid war—if possible—with an enemy capable of waging atomic war; to destroy his bomb-carrying vehicles before they reach our borders; and to disperse our people and our industries so that catastrophic results are avoided, if we are attacked.

We do not have to destroy the kind of life we have in order to survive. If we take these problems in time—looking at the situation calmly, and without panic; realistically, and without fear—we can establish a defense that will be invulnerable to decisive attack and the power of reprisal that will make attack virtually suicide for the aggressor.

Engineers' Role

These are some of the problems that confront us—as engineers—in the changing world of today. We must face the responsibilities laid upon us with open minds and with the courage of our convictions.

As consultants, we must advise those who plan to build large mechanical installations how to build in conformity with the needs of our national defense.

As engineers in a new world—we must be prepared to meet the challenge of change.

There is one thing we cannot do: We cannot turn back the pages of history.

Our job—as engineers and builders—is to make the future conform with those changes, so that the world of tomorrow will be better than it has ever been.

Our job—our most important job—as citizens with the training and knowledge to enable us to understand the problem—is to assist our fellow citizens to the utmost in the solution of this problem of dispersal.

Hermetic Motor Pumps for Sealed Systems

Experiences with "canned" motor-pump drive units developed to circulate water and other similar fluids in hermetically sealed systems having allowable leakage tolerances of substantially zero

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THE basic principle of the canned motor pump has been in use for many years. In earlier research investigations, where the necessity for pumping or sustaining the motion of a body contained within a hermetically closed system has utilized in some form this basic principle, its use has been limited to applications requiring relatively small amounts of power. Since the advent of atomic power, the problem of transferring energy by pumping large quantities of fluids in hermetically sealed systems has imposed greater demands on this type of pump.

The design and development of nuclear-power-plant systems capable of producing relatively large amounts of power has confronted the designer with a new challenge necessitating a still more critical review of our present engineering concepts in order that they can more effectively be adapted to their new environment. Some pumps are used to circulate liquid through the reactor, in this case a source of energy, and to a suitable steam-generating unit where the heat energy is removed and used to drive a conventional steam turbine.

Review of Several Possible Solutions[3]

To give greater assurance that the choice of the final pumping unit was the best consistent with the requirements given, a feasibility study was made to evaluate the possible methods presently available for circulating a liquid similar to water under the conditions outlined. Only a few of the possibilities considered are listed.

When considering the hydraulic aspects, water pumps may be classified broadly as gravity, centrifugal, positive-displacement, or jet types. For reasons of either capacity or head, the gravity, jet, and the postive-displacement pumps would not be feasible. However, the centrifugal-type pump, which is basically a simple and rugged machine, appears to be ideally suited for this condition. In general, a centrifugal pump has a high order of reliability which can be attributed primarily to its simplicity of construction. For a given capacity, the centrifugal pump usually is small in size, has good efficiency, is low in cost, is readily adaptable to high-speed electric-motor or turbine drive, and possesses a minimum of moving parts and bearing surfaces. Having established the proper hydraulic arrangement, a drive unit containing all the basic system requirements and capable of fulfilling the operating specifications can be chosen.

To simplify the choice of a drive unit, all drives may be classified as either hermetic or nonhermetic. Nonhermetic units are usually considered to operate through some form of shaft seal such as a conventional packing seal or a leak-off type normally known as a pressure breakdown seal. Most packing seals depend on the use of an elastic material as one element which can be forced into adjustment with the mating element, or by high precision of the mating surfaces at the seal faces. Such an arrangement usually presumes a given amount of leakage. Shaft sealing in the ordinary sense, where some type of packing gland is used against high pressure, has not been very successful because the requirements for intimate contact and the pressure between the mating surfaces usually create friction forces which exceed workable limits. As a result, the seal usually is destroyed by heat and wear. A controlled-leakage seal alleviates the heating and wearing problems by permitting a given amount of leakage to flow past the numerous surfaces, thus effecting a fair degree of lubrication to the mating parts. The pressure drop of the leakage flow through the clearance establishes the seal, and the total leakage in this arrangement is collected and usually pumped back into the system.

Hermetic drives may be classified as canned electric motors, flooded electric motors, hermetic pump and drive with seal interface, and hermetic turbine drive. A number of detailed variations are possible with any one of the four basic drives. Although the drive with seal interface may be considered a hermetic arrangement, the disadvantages of having the motor fluid, such as oil, leak into the system in the event of a seal failure could be quite serious. Disadvantages of a similar nature can be shown to exist with the hermetic turbine type of drive. The flooded electric-motor drive permits the system fluid to completely envelop both the motor rotor and the stator windings. Although the temperature of the water which is in intimate contact with the motor parts is at a much lower degree than the water being pumped, this arrangement also presents some basic difficulties which, of necessity, have been imposed by the system requirements. One of the difficulties is the rate of contamination resulting from the direct contact of the water with the motor insulation and the stator punchings. In system conditions having less stringent requirements, this arrangement would be considered

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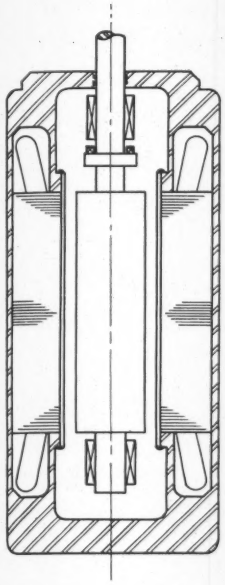

Fig. 1 Conventional canned induction motor drive

feasible. A modification of the flooded motor, but with the elimination of the disadvantages described, may be found in the conventional canned motor pump shown in Fig. 1. The insertion of a metallic can or diaphragm between the rotor cavity and the stator bore completely eliminates the contamination and corrosion factors found in the flooded motor.

Having previously assumed that the centrifugal pump is the hydraulic solution to the problem, when it is coupled with its component part, the canned motor drive, we have a feasible solution satisfying all the system requirements. With this combination, the corrosion, leak tightness, and the contamination factors are held to a minimum. The cross-section assembly drawing shown in Fig. 2 is a typical arrangement of a drive incorporating all the essential features described.

Design Chronology

The first canned motor pump designed and built by Westinghouse delivered 30 gpm at approximately 85 ft total head with a suction pressure of 2000 psig and water temperature up to 500 F. The motor was a 2-pole 3-phase 60-cycle induction motor rated at approximately 1.5 hp, with Class A insulation. The stator winding was totally enclosed by the frame on the OD of the stator iron, and the stator barrier tube or can through the bore of the stator iron. Heat caused by electrical and other internal losses was removed by flowing transformer cooling oil through the winding.

The stator can for this pump was made from a seamless, heavy-wall, extruded Inconel tube. This tube was machined to a minimum thickness of 0.040 in. through the bore of the stator iron and the thickness was gradually increased at the end sections (under the end turns) to provide sufficient strength to withstand the 2000 psig internal pressure. The stator can was welded to 18-8 stainless-steel end plates. Inconel was chosen for the stator-can material because of its high electrical resistivity, good corrosion resistance, fairly high yield strength, and ductility.

The bearings were necessarily water-lubricated since the rotor cavity was filled with water, and the bearing material used was Graphitar, a carbon-graphite compacted material. A bearing loading of approximately 15 psi was used, with a journal diameter of 0.875 in. and a rotor speed of 3400 rpm. Type 416 (13 per cent Cr) stainless steel was chosen for the shaft material since it possessed certain magnetic properties, which were required at the center of the shaft. A squirrel-cage winding was made of aluminum swaged into milled slots and connected to aluminum end rings by weldments made in an argon atmosphere. Since the rotor was not encased in a can, the propriety of using an unprotected aluminum winding was doubtful from a corrosion standpoint but proved to be satisfactory when the first pump was disassembled after approximately 3000 hr of service. Type 347 stainless steel was used for all wetted parts of the pressure casing with the exception of the Inconel stator can.

Two pumps using the "uncanned" rotor were built, but since the corrosion resistance of the aluminum squirrel cage was yet unknown, a solid-core rotor was designed for the next unit built. The core of this rotor contained neither slots nor damper bars. To obtain minimum electrical resistivity of the rotor, a hydrogen-annealed low-carbon-steel sleeve was shrunk on an 18-8 stainless-steel shaft. To prevent corrosion of the mild-steel sleeve, it was chrome-plated. Chrome plating was also employed on the journals to obtain higher hardness and to increase bearing life. On test, this rotor gave performance equivalent to the aluminum squirrel-cage

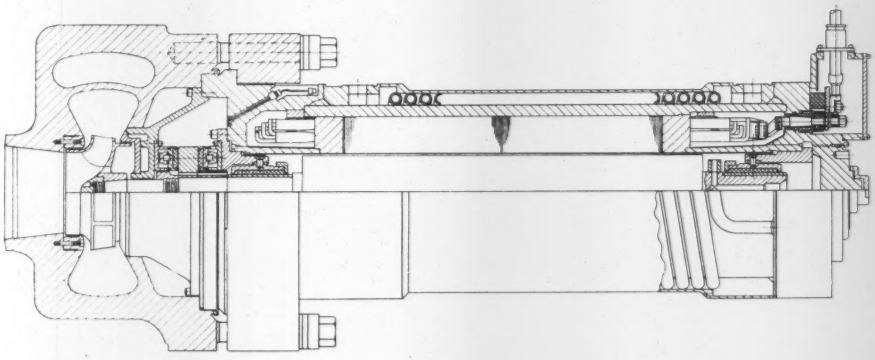

Fig. 2 Cross-section assembly shows typical arrangement of a 4000-gpm canned motor drive

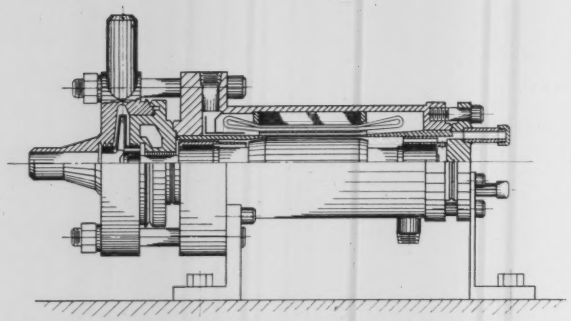

Fig. 3 Cross-section assembly drawing of Model 30-A totally enclosed centrifugal pump

rotor, but the chrome plating cracked and spalled at the junction of the soft-iron sleeve and the 18-8 stainless shaft. To eliminate this weakness, a solid one-piece rotor was built of type 410 steel (a magnetic corrosion-resistant steel). The shaft and core of this rotor were all one piece and it contained no squirrel-cage winding. This rotor proved to be less efficient than the two previous designs but was more easily manufactured and considered more dependable.

Another major component of the pump-motor unit was the thermal barrier, a flat disk made up of two plates welded together with an air space between them. The thermal barrier is located between the pump and motor, the motor shaft passing through its center. The function of the thermal barrier is to keep the water in the motor cavity at a considerably lower temperature than the water in the pump. This is accomplished by providing a high resistance to heat transfer by conduction and also by preventing any appreciable interchange of fluid between the pump and motor sections. Low clearances around that portion of the shaft which passes through the bore of the thermal barrier, and positive sealing of any return path, minimize constant leakage and interchange of hot and cold fluid.

The pump portion of the unit consisted of a single stage with a single suction overhung radial impeller. The impeller was completely fabricated of austenitic stainless-steel forgings, and was made by profile-milling the vanes on one shroud and then plug-welding the other shroud to the vanes. A sand-cast impeller was not used because of the inaccessibility of some portions of the internal passages for complete cleaning, an operation deemed necessary. The anticipated activity did not warrant tool costs for precision castings. All impeller surfaces, inside and out, were finished to at least 63 microinches in an effort to reduce friction losses and increase the corrosion resistance and reduce any possible erosion.

The pump casing was machined from a stainless-steel forging, and, for ease of manufacturing, a simple concentric casing was made in lieu of a volute, or logarithmic spiral type. Here, again, castings were not deemed advisable in view of the possibility of leakage due to porosity at the high internal working pressures.

The first units produced were given extensive engineering tests. These included pump performance, motor characteristics, hydrostatic pressure, rotor friction drag, and thermal-barrier tests.

After the construction of several units conforming to the original design, called the Model 30 pump, a few modifications were made, mainly in bearing design. Some difficulty was encountered in chrome-plating the journals, since they were actually radial and thrust bearings combined, a shoulder being used against the end of the sleeve bearing to take any axial loads. The chrome plating was failing in the corner of the shoulder and the journal outer diameter. A hard, flanged sleeve was substituted for the chrome-plating and the size of the bearing was increased by almost 200 per cent, subsequently reducing the unit bearing loading and increasing the journal velocity by approximately 70 per cent, both factors tending to increase the effectiveness of water lubrication.

The new journal materials used in place of chrome plate—both tungsten carbide and titanium carbide—performed satisfactorily.

Fig. 3 is a cross-section assembly drawing of the modified unit which is known as the Model 30-A totally enclosed centrifugal pump.

Some of the Model 30-A pumps have operated more than 24,000 hr in test service and, in general, have required little maintenance. No major difficulties have been experienced with the two most critical components of the unit—the bearings and the electrical winding. The bearing problem is mainly due to the requirement of water lubrication of reasonably high temperature. The electrical problem is mainly dependent upon the removal of heat from the winding end turns, with lesser considerations being a can in the magnetic gap, and an abnormally large gap. The friction drag of the rotor, due to the water in the stator bore, also contributes to higher losses than those in commercial induction motors.

A pump was required to satisfy the auxiliary pumping

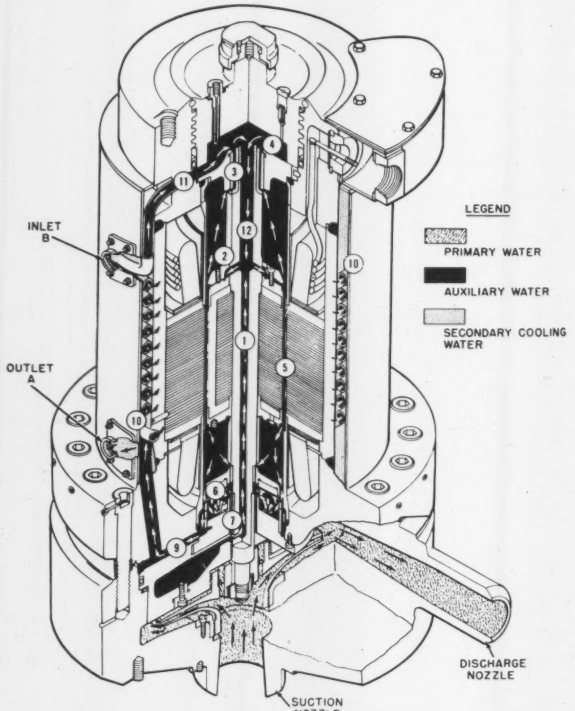

Fig. 4 Schematic flow diagram of Model 150-C pump

requirements for the Naval Reactor Project. Rather than make major modifications to the Model 30-A pump, a completely new and different unit was designed to produce 150 gpm at a head of 285 ft.

This pump was called the Model 150-B and was an improvement over the Model 30-A in the following respects:

1 No oil cooling; Silicone, Class H insulation was used and motor losses were removed by flowing fresh water over a coil containing primary water (fluid pumped) which is circulated through the stator bore and bearings.

2 Larger stator bore of decreased length making winding of the stator a more simple manufacturing problem.

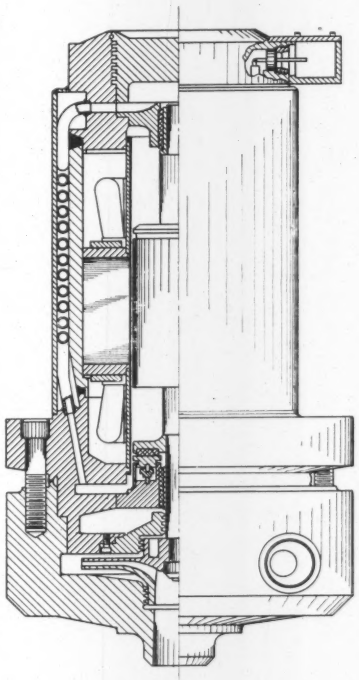

Fig. 5 Model 150-C totally enclosed centrifugal pump

3 Die-cast-aluminum rotor construction, reducing fabrication and machining costs.

4 Uniform-cross-section rotor and stator cans in contrast to the intricately machined Model 30-A cans with varying sections at each end.

5 Vertical machine with a pivoted-pad thrust bearing with a bearing area of 8 sq in. approximately 10 times that of the Model 30-A.

A modification of the Model 150-B pump was later produced and called the Model 150-C. The internal parts, connection dimensions (suction and discharge), and performance characteristics, remained unchanged. It may be noted that the over-all efficiency of the Model 150-C approaches 50 per cent, while the 30-A had a maximum efficiency of 15 per cent. This chiefly reflects the improvements made to the motor design.

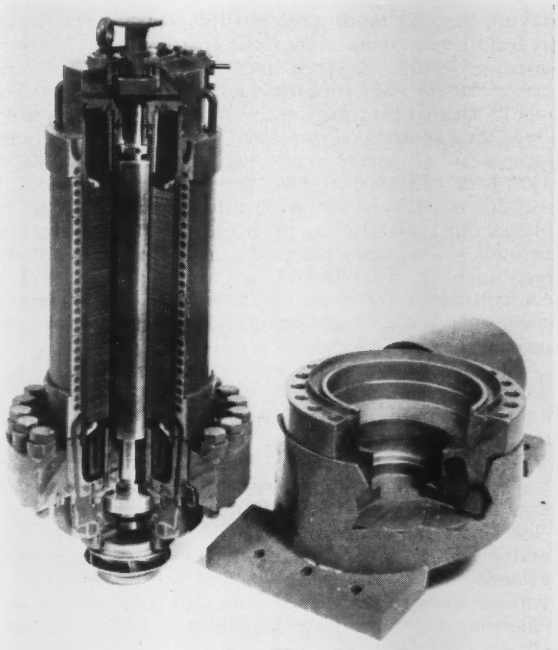

Fig. 6 Scale model of the 4000-gpm canned motor pump

Development of Model 150-B and Model 150-C Pumps

Basically, the 150-B and 150-C pumps are identical, with exception of the pump-casing closure. Fig. 4 is a cutaway view of the Model 150-C pump showing the flow paths of the cooling system. Fig. 5 is a pictorial cross-sectional view of the Model 150-C pump.

Description of 4000-Gpm Pump

A 4000-gpm pumping unit was designed and built to the following system requirements: The ambient operating-system pressure was 2000 psig. The corresponding temperature under these conditions was approximately 450 F. The liquid being pumped was water of extremely high purity. All materials in contact with the liquid were required to be highly corrosion-resistant. Because of the possibility of the fluid containing highly radioactive solids in solution, the necessity of having a system which could be shown to have, for all practical purposes, a zero leak rate was stipulated as one of the required design features.

The pump requirements for the foregoing system included these features: The hydraulic capacity at full power necessitated the pumping of 4000 gpm while developing a total dynamic head of 310 ft. From an operational standpoint the pump had to be designed to permit complete replaceability with a minimum amount of maintenance. This removable feature is shown in Fig. 6. It was required that the unit have a minimum weight and occupy a minimum space consistent with the high order of reliability considered essential for the operation.

Detailed Description

Hydraulics. To conform to the minimum weight and space requirements, it was necessary to obtain a drive

having the maximum speed possible, consistent with the hydraulic requirements and with the friction losses resulting therein. A speed of 3600 rpm was considered reasonable for the hydraulics under consideration. This would mean operating in the upper ranges of specific speed for a centrifugal impeller. The impeller, a Francis type with a specific speed of approximately 3000 at 3500 rpm and 1500 at 1750 rpm, was cast from 25.12 stainless-steel (type 309) with allowances for a considerable amount of machining in the vane passages and shrouds. This was done primarily to improve corrosion resistance by removing all surface impurities and by controlling surface finish. In addition to facilitating the cleaning prior to final installation, some improvement on efficiency also resulted.

The volute was fabricated from two forged parts which were welded together in a final assembly. A double volute design was used to compensate partially for the unbalanced pressure forces which exist in centrifugal pumps of this type. This was considered essential to the ultimate success of the water-lubricated bearings in the motor. The rigid requirements on leakage, cleanliness, and corrosion resistance were some of the major factors governing the choice of a forged volute construction. As a by-product of this construction, it was possible to realize some gain in over-all hydraulic efficiency since the internal passages could be held to close machining tolerances and the surface finish held to any degree desired. The volute was also designed to permit testing under actual operating conditions with the use of conventional gaskets. A weld lip which is machined integral with the volute is used during the final installation stages to obtain a hermetic type of seal between the pump and the motor drive at this joint. To insure the leak tightness of this final joint, helium at 300 lb is introduced between the weld and the gasket and mass spectrometer check is made of the outward leakage. The volute contains 22 tapped holes which are used to clamp the motor drive to it. This clamping arrangement is designed with sufficient capacity to withstand $1^1/_2$ times the operating pressure when using conventional gaskets. In addition, sufficient bolting capacity has been added to withstand high shock loads without any outward leakage at the gasket or overstressing of the seal-welded joint.

Immediately above the impeller a bell-shaped thermal guard is mounted on the lower end of the motor drive. In addition to supporting the weight of the rotor and the vertical thrust reaction of the impeller, the thermal guard serves two other purposes. It functions as a barrier to effect a thermal gradient between the water being pumped and the water which is essentially contained within the motor proper. Second, it retains a labyrinth-type shaft seal between the pump and the motor which, for all practical purposes, is the only passage or communication between the fluid being pumped and that contained within the motor. Normally any exchange across this gland is one resulting from diffusion or small pressure fluctuations which may occur during operation. The temperature of the water enclosed within the motor immediately behind the thermal guard is held to a minimum of approximately 200 F.

Bearings.[4] As indicated in Fig. 2, the radial bearings are essentially of the hydrodynamic sleeve type made self-aligning to accommodate any misalignment resulting from initial machining tolerances or distortions due to nonuniform temperatures. The radial bearings consist essentially of a Graphitar 14 sleeve contained within a stainless-steel cylinder which subjects it to a compressive stress in all directions. This arrangement gives maximum protection to the material both during the initial fabrication stages and later during operations when the unit may be required to absorb shock loads. The bearings have undergone a series of high shock-load tests without any appreciable damage that would render them inoperable. The self-aligning feature of the bearings is achieved by providing a spherical portion on the bearing cartridge which in turn is mated to a cylinder of Stellite mounted into the bearing housing. Two diametrically opposite pins are added to absorb the torque on the bearing and to support the bearing cartridge vertically. The journals consist of nitrided stainless-steel sleeves which are shrunk on the rotor shaft. Both the bearing and journal surfaces are ground and lapped to a finish of 10 microinches or better. Bearing lubrication and cooling are assured by providing a pressure drop across the axial length of the bearing by fluid circulated from a small auxiliary impeller that is an integral part of the rotor.

The vertical thrust loads are absorbed by a double Kingsbury arrangement at the lower end of the rotor. Under normal conditions the lower Kingsbury takes all of the thrust load; however, under certain conditions of flow the thrust may be negative at which time the upper Kingsbury will take the reaction. The thrust bearing is of the fully equalized type containing six shoes of Graphitar material retained by a stainless-steel pocket of proper shape and size. The runner is made of stainless steel with the bearing surface nitrided, ground, and lapped similar to the journals. Under normal operating conditions, the bearing pressures encountered in thrust may vary from 20 to 40 psi.

Thermal Considerations. The three major sources of heat generated within the unit which must be removed by external means are electrical, hydraulic, and thermal. The main electrical losses consist of the copper or I^2R losses, iron or eddy current, stator can, and rotor losses. Those generally associated with hydraulics are the fluid friction, of which the air-gap component is the largest, bearing losses, and the fluid friction of the internal circulating system. The thermal losses consist of normal conduction, radiation, and convection losses resulting from the inherent close couple between the motor drive and the pump proper.

The magnitude of these losses makes it impractical to rely on normal means of heat dissipation, such

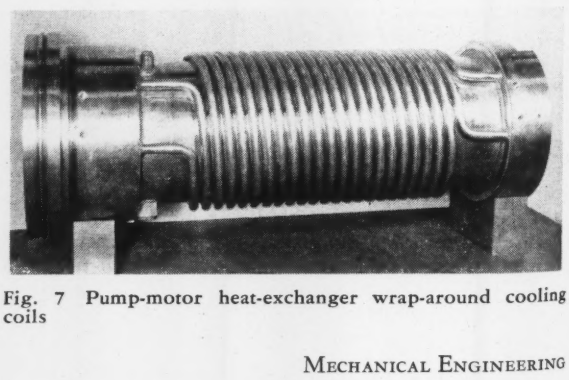

Fig. 7 Pump-motor heat-exchanger wrap-around cooling coils

[4] "Water-Lubricated Bearing Development," by W. M. Wepfer and E. J. Cattabiani, MECHANICAL ENGINEERING, May 1955, pp. 413–418.

as external radiation and convection as normally used in conventional motor design. A low-pressure fresh-water heat-exchange system, a part of which is built integral with the motor, is used to remove the excess heat. Fig. 7 shows the wrap-around cooling coils of the heat exchanger prior to welding on the fresh-water cooling jacket.

The total amount of heat energy removed from the drive, including the thermal losses mentioned previously, is approximately 85 kw. This consists of the copper, iron, and can losses which are approximately 45 kw; windage and friction losses approximately 20 kw; conduction and radiation losses from pump volute about 5 kw. The balance of the losses is attributed to the heat exchange, which takes place at the labyrinth shaft seal, of the 450 F water with the 200 F water in the motor hydraulic circuit. The two major losses, stator can and water friction, are readily transferred to the heat exchanger as a result of the internal water circulating method provided by the auxiliary impeller which circulates approximately 40 gpm in this closed circuit. The fluid circulating within the air gap is used to cool the stator can, rotor, radial, and thrust bearings. Additional energy is provided by the thermal and radiation losses at the thermal guard plus the heat due to the interchange at the rotating seal. The fluid then enters a coiled heat exchanger consisting of four parallel paths which discharge into the suction of the auxiliary impeller at the top of the motor to complete the cycle. The low-pressure fresh-water system surrounding the coiled tubes requires 25 to 30 gpm at 10 psi pressure under normal operating conditions.

To facilitate the heat removal from the end turns of the electrical windings, an additional metallic path has been placed in parallel with the end turns. Copper fins are inserted between the ground insulation of every coil layer at the end turns. The fins are brought into intimate contact with the motor frame which operates at a temperature slightly higher than that of the cooling water. The I^2R losses in the end turns are further reduced by increasing the wire cross section at this location to approximately 75 per cent more than the wire in the stator slots proper. The hot-spot temperature during normal operating conditions was recorded to be approximately 160 C measured by thermocouples embedded between coil layers spaced along the end turns. The water temperature in the air gap and surrounding the bearings is approximately 150 F and is recorded by thermocouples located at various points within the motor.

Fig. 8 shows cooling curves of the unit operating at 900 rpm circulating approximately 1000 gpm water at 450 F but with the cooling water to the heat-exchanger jacket shut off. It is interesting to note that when operating at this speed, the heat losses generated within the unit may be dissipated to the surrounding atmosphere in a manner similar to that of conventional motors under proper environmental conditions.

Miscellaneous. The motor is basically a squirrel-cage induction motor wound with Class H insulation and operated from a 440-volt three-phase source. The rotor is fabricated from a solid forging of type 410 stainless steel. Slots are milled into the surface of the rotor for copper bars and copper resistance rings all brazed to the bars at each end. The assembly is finally sealed by "canning" with a 0.020-in-thick Inconel tube or "can." A considerable amount of development has been carried out on cans to improve their reliability and to insure reproducibility of the end product. Special leak-testing procedures have been devised to give further assurance of a high-quality product. The can is shrunk onto the rotor with an interference fit ranging from 0.005 to 0.010 in. on a rotor that is approximately 7 in. in diam and 30 in. long and seal-welded at each end.

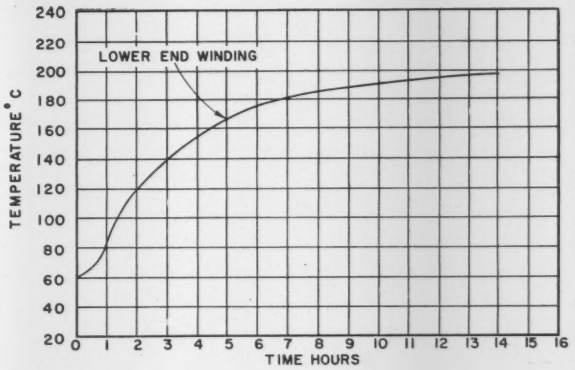

Fig. 8 900-rpm operation of hermetically sealed canned motor pump without external motor cooling water

The stator coils are of the preformed type and are assembled into the stator by dropping them into open slots in the conventional manner. The stator bore is finally sealed by the insertion of a 0.020-in-thick can that extends throughout its entire length and is seal-welded at both extremities. The completed unit is given a hydrostatic test of 3750 psi followed by a mass-spectrometer leak test using 2000 psi helium internally and a mass spectrometer connected in series with the electrical winding cavity.

Since the stator can was the only barrier containing the system pressure, it was considered desirable to have a back-up protection in the event that the can was ruptured as the result of some extreme unforeseen conditions. To this extent, the outside motor shell and the motor terminals have been designed to withstand full system pressure.

Test Results

These units have been subjected to extensive laboratory tests in loops which were designed to simulate actual operating conditions. In order to evaluate properly the degree of effectiveness to which each component was functioning, a number of isolated tests were conducted, each yielding the specific data required. Some of these will be described briefly and results shown. To facilitate maintenance, particularly in removing a pump from the system, heater-type bolts similar to those used in turbine practice have been used. To insure uniform clamping and thereby insure both a leaktight gasketed joint with minimum distortion, it was imperative that bolt loads be applied uniformly within close tolerances. Tests were conducted on a number of bolts to ascertain the repeatability of final bolt load when turned through a given prescribed angle. This arrangement has resulted in substantially reducing the time required for assembly and disassembly of the unit.

In single-suction pumps it is almost always necessary to provide some means of absorbing the unbalanced axial thrust caused by hydraulic factors. This thrust results from the fact that the area opposite the impeller eye

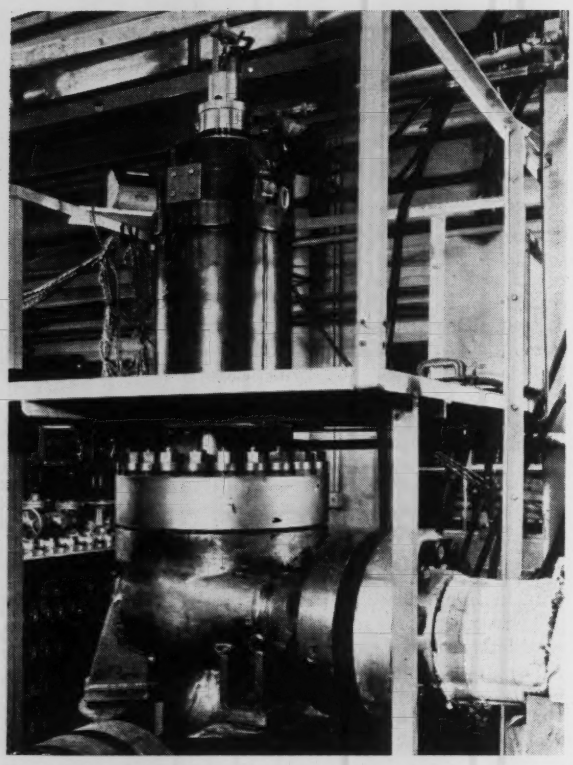

Fig. 9 Canned motor pump in loop undergoing thrust tests

is at suction pressure at the front of the back shroud and at discharge pressure at the rear of the back shroud. This results in a force tending to move the impeller toward the suction.

Generally, it is not too essential that one accurately know the extent of the hydraulic axial thrust load from centrifugal impellers of this type, since the axial loads are normally carried by some external means through an externally oil-lubricated thrust bearing or through suitably designed ball bearings in the motor drive unit. However, the inaccessibility of the bearings together with their inherent lower load-carrying capacity, as compared with conventionally oil-lubricated types, made it desirable that loading conditions be measured experimentally. Fig. 9 shows a pump in the test loop undergoing thrust tests. The thrust-measuring instrument is shown mounted in position at the top of the pump. The test setup consisted essentially of making connection with the upper end of the rotor through a rotating internal couple and sliding shaft seal. Externally this is connected to a stationary strain-gage weigh bar so arranged as to record a tension load that is proportional to the hydraulic thrust imposed by the impeller. By making due allowances for the rotor weight, and friction at the sliding seal, one can predict, with a fair degree of accuracy, the thrust load on the bearing under all conditions of operation.

Some of the main difficulties encountered in the early manufacture of canned motor pumps were concerned with the leaktightness of the stator assembly, or more specifically, the welding. Inconel, Inconel "X," and austenitic stainless steels are not considered as ideal welding alloys, especially when joining sections of appreciably different thickness, as in the case of welding rotor and stator cans, to substantially heavy end flanges and end plates. All of the seal welds (as differentiated from structural welds) are now of the machine or automatic type with little left to human error or technique. As a result of the criticality of the welds, the rotors, stators, and completely assembled pumps are given extensive leak tests, including hydrostatic pressure tests; helium leak tests employing a mass spectrometer type of leak detector and high vacuum technique; and a high-pressure helium test using the leak detector to pick up any helium passing through a welded joint or flaw in the base metal.

Conclusions

During the development and manufacture of the canned motor pumps discussed, every effort was made to use standard commercial practice and materials where acceptable. Many times slight modifications of commercial practice were required, but a large number of new techniques and processes had to be developed and tried, and many relatively new materials were employed. Some specific examples of this were the welding and leak-testing techniques and all the associated fixtures; the fabrication and sizing of rotor and stator cans by various methods such as rolling, welding, and sizing, or rolling and welding with successive bench-drawing operations; and the ultimate production of seamless cans by deep drawing. Material problems involved the use of carbides, precipitation-hardening stainless steels (18-8W and 17-4 PH), age-hardened Inconel "X" and Inconel "W," and the compatibility of materials in contact while immersed in moderate and high-temperature water. Auxiliary tests were run on bearings, and mock-ups were made of small components such as terminals, back-up sleeves, rotor cores, and difficult welds.

The description and operation of canned motor pumps have thus far been discussed in terms of their performance in high-pressure high-temperature water systems. Pumps of the 4000-gpm size have been operating successfully for approximately 12,000 hr to date. In addition, the units have been subjected to numerous starts and stops and low-speed operation in order to better evaluate bearing life under actual conditions of operation. Smaller pumps having the same basic design features have been used to circulate other fluids, and it is believed that their field of application will continue to expand. It is anticipated that canned motor pumps will play an important role in the future of atomic energy, and with increasing time, their use will continue to be extended to other fields where the requirements of hermetically sealed rotating apparatus is of paramount importance.

Acknowledgments

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The authors acknowledge the contributions of many individuals of the Westinghouse Electric Corporation who so willingly participated in this development.

Active participation of the Westinghouse Transportation-Generator Division, Steam Division (Condenser Subdivision), the Buffalo Motor Division, and consultation furnished by the Research Laboratory personnel have been extremely valuable.

Of What Use Are Chemical Treatments in Controlling Corrosion?

An evaluation of products now being offered widely for the solution of numerous problems in the field of steam-generating equipment

By S. T. Powell[1] and L. G. von Lossberg[2]

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A NUMBER of products now being offered to supplement primary water conditioning and mechanical deaeration in steam plants serve useful purposes. Among these are compounds for corrosion control. Boilers, equipment integral with the boilers, and units in the entire steam and water cycle can be protected against corrosion when the proper water-conditioning controls are provided. However, some internal treatments may have little or no value; in fact, unwise selection of chemicals for secondary treatment actually may result in operating difficulties.

Classification of Chemical Reagents

Chemical reagents employed for corrective treatment of feedwater and boiler water may be classified broadly in three major groups for convenience in the present discussion.

These are as follows:

(*a*) Chemicals for internal softening, sludge conditioning for inhibition of silica scale of objectionable types.

(*b*) Reagents used to remove oxygen or inhibit its effect in corrosion.

(*c*) Miscellaneous inorganic and organic materials for minimizing corrosive attack on metals.

The present discussion is limited to conditioning chemicals in groups (*b*) and (*c*). It is recognized that such arbitrary classification cannot be applied dogmatically to all treatment chemicals, since some serve a dual purpose.

Chemical Deoxygenation

All power-station operators are aware of the imperative need for oxygen removal from feedwater, as well as the desirability of controlling carbon dioxide and ammonia in the steam-water cycle. These gases, in addition to nitrogen, constitute the principal noncondensable gases normally present. Realization of the need for the removal of noncondensable gases was manifested at an early period in the history of steam generation. This was the basic reason for the development of the open (nondeaerating) heaters and subsequently deaerating feedwater heaters. More recently, deaerating hot wells for surface condensers have been developed for effecting adequate degasification.

Open heaters marked a significant advance in deaerating feedwater for low-pressure boilers, but they did not inhibit corrosion completely. For more effective protection of equipment, deaerating heaters of the counterflow tray or atomizing type, or a combination of these well-established designs, were developed. Finally, supplementary chemical treatment subsequent to deaeration was adopted.

The trend to higher-pressure boilers demonstrated the need for secondary chemical treatments which are now generally recognized and accepted.

Sulphur Compounds as Reducing Agents

For a number of years, sodium sulphite has been the chemical most extensively used to effect complete oxygen removal from the feedwater in both high and low-pressure steam-generating plants.

The value of sodium sulphite for minimizing corrosion has been demonstrated so frequently that little confirmatory proof is necessary to justify its use as a reliable deoxygenation chemical. A single illustration should suffice. Reduction in boiler-tube losses in one plant following the use of sodium sulphite is shown in Fig. 1. The tube failures were traced to oxygen in the feedwater. Losses were exceedingly heavy prior to sulphite treatment, but were reduced steadily until practically no losses were experienced.

Certain difficulties which have been experienced in connection with the use of sulphite resulted in the abandonment of this treatment in a few high-pressure plants. Claims have been made that sulphite treatment has been responsible for attack on boiler feed pumps, turbines, condensate return lines, and miscellaneous auxiliary equipment. Although the basis of these objections is sound in some cases, the difficulties experienced have been due in large measure to inadequate control.

Extensive investigation on the rate and extent of decomposition of sulphite in high-pressure boilers has supplied much valuable information on control procedures necessary to prevent or limit the generation of sulphurous acid or other acidic-sulphur compounds in the

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condensate. Recorded data show that in boilers operating at 1000 psi and with a boiler-water pH of approximately 11.0, it is desirable to maintain a sodium-sulphite concentration of not over 10 ppm to control the decomposition of sodium sulphite.

Following this investigation, it was found that, in boilers operating at pressures of 1200 to 2000 psi, the breakdown of sulphite is so rapid that it is desirable to hold the sodium-sulphite concentration in the boiler water to a maximum of 5 ppm.

Use of Sulphite-Treated Water for Desuperheating

For some time, boiler and turbine manufacturers have resisted the use of chemically treated feedwater in desuperheaters or attemperators to control final steam temperature. It is obvious that the introduction of appreciable amounts of solids into the steam cycle by means of chemically treated water is an objectionable practice which should be avoided.

In many steam-generating plants where relatively satisfactory mechanical deaeration is effected by heaters or in condenser hot wells, and where deoxygenating chemicals are employed to remove small traces of residual oxygen, sulphite-treated condensate is being used for desuperheating with no adverse results. Sulphite-treated desuperheating water has been used for a number of years without any difficulty at numerous stations with which the authors are familiar.

It is complicated and costly to provide a separate supply of deaerated water, of condensate quality, for desuperheating. For this reason, some operators prefer to use boiler feedwater (which has not been chemically dosed) from the discharge side of the boiler feed pump for desuperheating. The sulphite is applied to the feedwater just ahead of the boiler or directly into the boiler drum. We have ample evidence that such practice is conducive to metal pickup in the preboiler system, thereby foregoing maximum protection which the secondary chemical treatment can provide.

It is the authors' opinion, based on analyses of data of numerous stations, that, when conditions are appropriate, less operating difficulties will be experienced from well-controlled sulphite addition to feedwater (which is to be used for desuperheating) than from addition of the chemical to the boiler.

Hydrazine Treatment

Limitations just cited have led in some cases to the use of hydrazine to replace sulphite. This chemical mildly increases the pH of the feedwater, removes oxygen, and, under favorable conditions, decomposes into nitrogen and water vapor.

Table 1 Physical and Chemical Data on Hydrazine Solution

Active ingredient, 54.4 per cent N_2H_4, formula weight 32

Typical analysis:

N_2H_4	54.60 per cent
Cl	0.03 per cent
H_2O	Balance

Appearance: colorless liquid
Pounds per gallon at 25 C: 8.59
Solubility: completely miscible in water
pH of 1 per cent solution at 25 C: 9.9
Melting point: minus 57 C
Boiling point: 119.8 C
Flash point, open cup: 193 F
Fire point, open cup: 205 F

Hydrazine, N_2H_4, is used as a rocket fuel and for

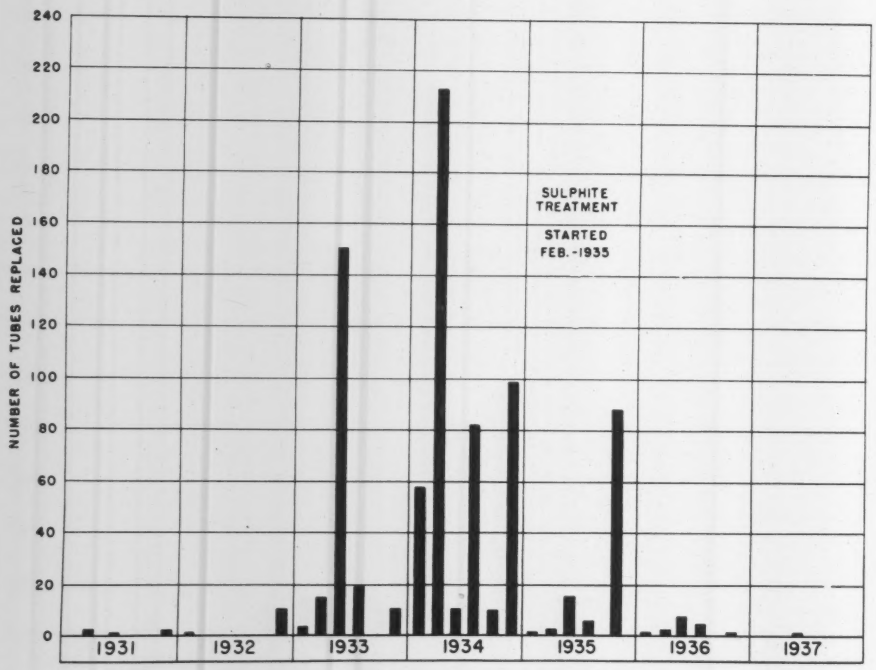

Fig. 1 Tube losses in six boilers of central power station before and after sulphite treatment

limited industrial applications. The anhydrous material is a powerful reducing agent, and its handling presents an explosion hazard. Dissolved in water the hydrazine forms a hydrate and this is the most favorable form, thus far, for using the material to remove oxygen from water. Further, the hydrate is relatively nonhazardous.

For feedwater conditioning at moderate temperatures and low concentrations, the hydrate reacts with dissolved oxygen to form water vapor and nitrogen. At high temperatures and relatively high concentrations, the hydrazine decomposes into nitrogen, ammonia, and water. Elevated pH values and temperatures and catalytically active surfaces favor a rapid speed of reaction and a conversion into the desirable products, namely, nitrogen and water. Physical and chemical data pertinent to the commercially available solution of hydrazine hydrate for boiler-water treatment are shown in Table 1.

Several steam stations have adopted this type of treatment and it is apparent that its application will expand as more experience is gained in practice.

Increased use of hydrazine during the past few years is shown by the graphic record presented in Fig. 2. In 1951, only one station in the United States had adopted this treatment, but by 1954, 22 stations had introduced this type of conditioning. It is indicated that many more stations, especially those operated at high pressures, will initiate this form of treatment.

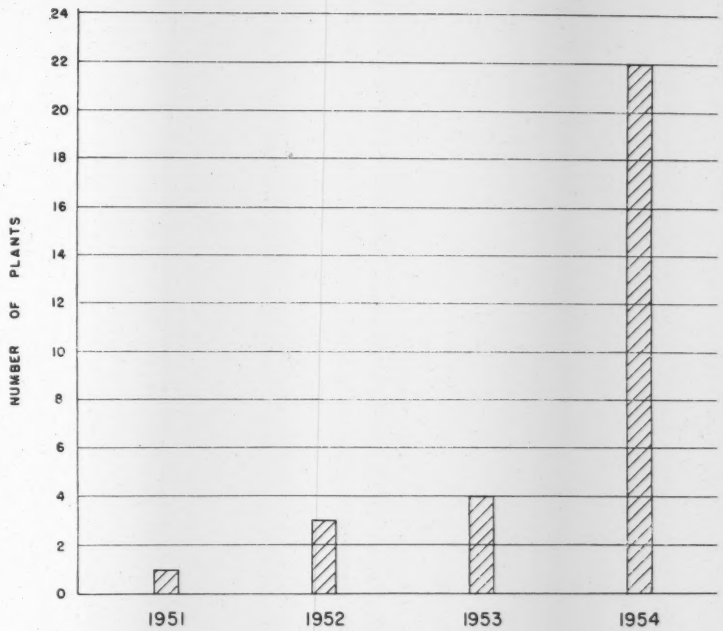

Fig. 2 Number of plants using hydrazine. The data are limited to plants in the United States using hydrazine for boiler-feedwater treatment

Operating Experience

At one location, a 1400-psig station, where hydrazine was first fed to the effluent of a deaerating hot well at the rate of about 0.3 ppm for a short time, the ammonia increased from 0.06 ppm to 0.6 ppm. When the hydrazine feeding rate was decreased to half and then to one third of this amount, the ammonia concentration decreased correspondingly to 0.3 ppm and then 0.2 ppm. These conditions represent initial results of applying the treatment.

At another 650-psig industrial plant where hydrazine hydrate has been applied by feeding a very dilute solution to the effluent of the deaerating heater, the results after reaching an equilibrium condition are as follows: Hydrazine as N_2H_4 in the boiler water is about 0.04 ppm; no ammonia in the steam due to decomposition has been detected; conductivity of the steam condensate has reduced several micromhos; and the pH value has increased about 0.2 since starting the treatment.

In a southern commercial industrial boiler plant, hydrazine application was one of the principal corrective measures effected to prevent costly tube losses. Several other changes involving water quality, heat distribution, and circulation in the boilers were made simultaneously. Complete elimination of dissolved oxygen from the system, improvement in the pH value of the condensate returns, and the reduction in black iron oxide throughout the steam and water cycle has been revealed by operating records and inspection. However, the foregoing physical changes also had a marked influence on the elimination of tube losses.

Hazards

There is much misconception and confusion pertaining to the hazard that hydrazine compounds, used for feedwater treatment, present to operators and to the equipment. As stated earlier, anhydrous hydrazine is a dangerous material and as such should not be considered for power-station use. Hydrazine hydrate in 35 per cent solution does not emit corrosive fumes, has no flash point at room temperature in an open container, and is less objectionable than, for instance, ammonium hydroxide or some volatile amines.

Hydrazine hydrate is not corrosive to iron or steel when diluted to 35 per cent, and requires no greater care in handling than many other water-conditioning chemicals used in steam-station practice. Fig. 3 shows equipment for safe handling and feeding of hydrazine and other volatile liquid chemicals. However, some persons are allergic to even dilute hydrazine solutions.

pH Control of the Condensate Returns

Gases other than oxygen enter the feedwater cycle and are not removed completely by deaeration. In this connection, dissolved ammonia and carbon dioxide are the two principal constituents meriting consideration. Small amounts of ammonia, to increase the pH of the condensate return to approximately 9.0, have been used for many years in Germany and in Sweden and more recently in this country. Both ammonium hydroxide and ammonium chloride are added to the feedwater to increase the pH value and neutralize carbon dioxide in the condensate.

Pure, well-deaerated condensate has a pH of approximately 7.0. With only fractions of a part per million of either sulphur dioxide or carbon dioxide present, the pH is depressed appreciably below 7.0, and more rapid corrosion of ferrous and nonferrous metals occurs. Thus the use of volatile alkaline amines to increase the pH of the condensate has gained considerable popularity during the past few years. These amine treatments have been most effective in central power plants where the condensate is relatively pure and only slight traces of acid anhydrides are present.

Numerous tests have supplied statistics on normal ranges for the quantity of iron and copper in the condensate of power stations where the metal pickup by pH adjustment is either controlled or uncontrolled. Frequently, iron is present within the range of from 0.1 to 0.3 ppm in plants where there are measurable amounts of dissolved oxygen in the condensate and the pH value is less than 7.0 due to carbon dioxide. The concentration of copper in the condensate also falls within this range, but tends to approach the lower figure quoted. When dissolved oxygen is removed and the pH is raised by ammonia naturally present or by amine treatment, more favorable results are obtained. The iron pickup can be reduced to between 0.01 and 0.04 ppm and copper between 0.002 and 0.02 ppm. Naturally, the iron and copper concentrations vary from plant to plant, but these figures serve to reveal the magnitude of the range prevailing when the amine or ammonia treatment is effective.

Use of Amines in Power Plants

In central power-plant practice, today, the use of amines is one of the several refinements effected to improve operation and protect the metal in the system. It is indicated that, of the various volatile amines, morpholine is favored for pH and corrosion control in the steam-water cycle, because this chemical apparently has a more satisfactory ratio of distribution between the vapor and liquid phases than ammonia or other amines used for this purpose. The feeding rate for morpholine is less than for either ammonia or cyclohexylamine to maintain the required pH of the condensate, especially the first-formed condensate in the turbine. There are other volatile amines, such as diethanolamine and triethanolamine, which have favorable distribution ratios. Unfortunately, these materials attack copper.

Waxy amines which form a protective film over the entire steam-distribution and condensate-collecting system have been used to some extent during the past four or five years. Their application is being extended to many plants. The treatment seems to give favorable results in low-pressure steam-generating systems. The protective film formed is maintained intact and is self-healing as long as more than a critical low concentration of the volatile filming amine is maintained in the steam and condensate returns. Excellent results have been reported in numerous low-pressure plants. In one plant the formation of films on critical boiler tubes has been attributed to the amine. The same difficulty also has been experienced with other organic internal chemical conditioners. Although few cases of this type have been reported, it is a possibility which should be evaluated in the use of the organic treatments.

Attention is drawn also to the fact that in direct application of feedwater to superheated steam for desuperheating or attemperating, the possibility must be considered of decomposition of the amines in the finely divided state in which they contact hot steam.

Conclusion

Comments made in this paper, as earlier indicated, are primarily a historical review, so presented as to direct attention to the trends in supplementary chemical treatments. The intent has been to present unbiased factual information.

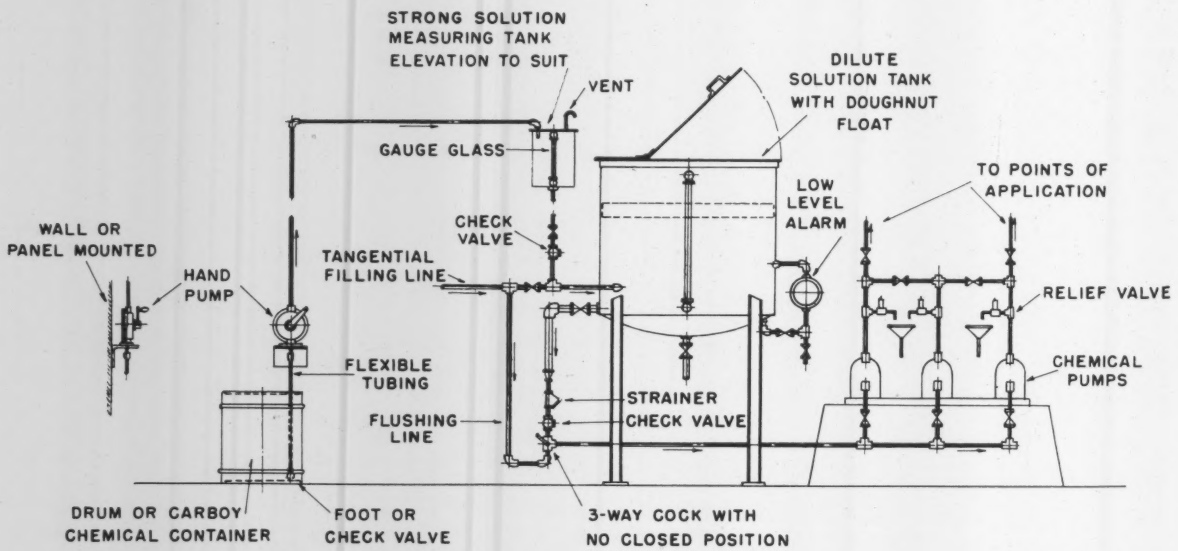

Fig. 3 Arrangement of equipment for safe handling and feeding of strong chemical solutions after dilution

Human Relations in Industry

By Lydia G. Giberson, M.D.

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Enlightened management has come to the realization that the success of a business depends on well-adjusted human relations from the top executive down to the humblest worker in the company. It is management's task to correct the inequities that exist in the ranks of its personnel, to discover and alleviate the maladjustments, to solve the problem of the psychoneurotics who inoculate large groups of otherwise efficient workers with their aberrations. Imponderable as the human factor in industry may be, it is the most important in a free society—and industry will do well to recognize this basic fact.

It is regrettable that in the quest for new methods, better techniques, and greater over-all efficiency, the interdependence of the human beings who must apply them too often has been lost in the shuffle. Gears are machined often to a tolerance of one one-hundred-thousandth of an inch for their smooth functioning. Hence the interdependence of the working parts assumes vital significance.

But what of the human being, who, in the final analysis, must get the most out of these machines. Since he is not a machine himself, his tolerances cannot be computed by slide rule or test-tube experiments. He can be measured only in the understanding that one man may give another, and here is the true meaning of interdependence.

Recognition of the Individual

There is no Utopian scale for measuring the imperfections of man himself, and in this connection it is interesting to note that, as far back as 1916, Henri Fayol, noted French engineer and industrialist, recognized this fact, and with true Gallic verve expressed it this way:

"Maintain toward workers a polite and kindly attitude; set out to study their behavior, characters, abilities, work, and even their personal interests. Remember that intelligent men are to be found in every walk of life. With capable leadership there is obtained not merely discipline but loyalty of every kind, which may, in difficult or dangerous circumstances, reach abnegation and sacrifice of self."

All workers are human beings, with individual temperaments, needs, hopes, fears, problems, skills, abilities, and idiosyncrasies. All men strive for dignity, self-respect, self-expression, security, and the desire for the esteem of their fellow men. Translated into industry, all workers seem to want the following:

Justice. A sense of being treated fairly, fair wages, reasonable hours, decent working conditions, safe working conditions, and adequate protection against sickness and disability. Administration of justice must be obvious, courageous, and prompt.

Status. Workmen want their jobs recognized as of some importance in the scheme of things. They want to feel "they belong."

Opportunity. The sense of "going somewhere"—of progress. The proportion though of average workers who really seek advancement with responsibility is smaller than is commonly realized.

Security. The desire to feel reasonably secure in their employment. If we are to work together, industry's human relationships with its workers must be cooperative, creative, and productive as possible.

Problem of the Industrial Misfit

About eighty per cent of all employees function smoothly and consistently over the years, with only normal lapses for tardiness, illness, or whatever cause. The remaining twenty per cent make up the group in which management problems multiply. To this 20 per cent group almost exclusively belong the apparently inexplicable absenteeism, accidents, troublemaking and, in general, those factors upsetting the routine. Simply to label these individuals in the 20 per cent group "problem cases" or misfits is not enough. They are really maladjusted in almost every instance. By maladjusted I mean the individuals are emotionally upset or emotionally unfit for their jobs, at least temporarily. These emotional disturbances can arise from physical causes easily discernible to a good medical diagnostician, or the causes may be purely psychological in origin, the product of an unassimilated personality or of social pressure upon the employee outside the job.

The term misfit as it applies to any job in industry describes only the end result of a series of circumstances. Since an individual in an industrial society is in great measure a product of that society, the opprobrium of the term then falls on him.

The spawning ground of the misfit is a vast and intricate network composed of sociological, physical, mental, and psychological factors originating, and it is important to remember this, with management as well as with the individual employee.

There are certain discernible conditions that are sociological in nature such as heredity, background, education, home conditions, finance, and status in the community; physical conditions such as individual

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handicaps (poor eyesight, defective hearing, chronic diseases such as tuberculosis, diabetes, and so on); working conditions that include occupational hazards; mental conditions (epileptic fits, sleeping sickness, manic depressive psychoses, and so on); psychological conditions (insecurity, anxiety, worry, and fears).

Causes of Job Failures

Such a simple thing as defective eyesight may impair an employee seriously by creating headaches and excessive errors. Illness such as tuberculosis, diabetes, glandular upsets, hardening of the arteries, and so on, may contribute to job failure. These disorders lower the employee's productivity. All take a toll of physical strength, creating early fatigue, irritability, perhaps outbursts of temper and gross errors in judgment.

The employee's physical surroundings on a job may contribute to his becoming a misfit or problem. Cold, ill-lighted, badly ventilated, or dirty factories, with little or no attention paid to occupational hazards, may subject him to more than ordinary stresses, impair his morale, and bring about an emotional upset.

Nervous disorders, organic or functional, must be included as important factors in job misfits. In many instances the functional disorders remain latent for years. They are so deeply buried that even excellent selection technique cannot detect them. It is only later when the employee is subjected to pressure on the job, severe shock such as death, fire, financial disaster, or similar difficulties, that his maladjustments begin to manifest themselves.

Management's Responsibility

An employee's sense of insecurity, his anxiety, his worry and fears cut deeply into his efficiency and productivity. Much of this is created by the impact on himself of his superiors and his fellow workers. Management's responsibility is great in the picking of proper supervisors or foremen, for here is "the company" to most employees.

All of this is not an implied criticism of management as such, or the personnel composing it, but since, in the final analysis, it is management's responsibility to achieve the smoothest possible functioning of its enterprise, it becomes management's province to understand and at least attempt to correct the factors recited.

No discussion of problem employees would be complete without some mention of psychoneurotics. Psychoneurotics are emotionally immature individuals. There is a definite fixation of the attention upon the individual himself, and an emotional reaction all out of proportion to his difficulties. Too often his symptoms are a direct play for sympathy and attention, or an excellent alibi for failure in a given situation. These individuals translate their disappointments and difficulties into physical symptoms.

When the psychoneurotic or "problem" employee is not obviously ill enough to be away from work, that is just the time when he is most costly to an organization. Not only do these men lose time in astonishing amounts by themselves, but their lowered efficiency and emotional distortion affect sympathetically all those around them, and the morale and working efficiency of a whole group may be lowered seriously by the continued presence of just one of them.

The psychoneurotic, who is really a sick person, shows many symptoms that seem willfully detrimental to business efficiency. The attitude of inferiority, the chronic fault finder, the overdependent employee, the daydreamer, the worrier, the chronically nervous, the excessively fatigued, all these belong in the medical group roughly termed hysterical, and they account for the largest percentage of all time lost from work because of illness.

Occasionally in an industrial organization emotional upsets appear in greater numbers from one specific department. This may be due to a maladjusted foreman or section head who has been upsetting his subordinates. It is important to remember that executives and supervisors are human beings and subject to the same rules of human adjustment. If they are unstable and maladjusted the results may be devastating to the hundreds under their control. Detection and disposition of maladjustments in high places may demand more tact than average cases, but the principles and methods are the same.

The Executive's Task

Most men have within them the ability to perform well a given task; many men have the ability to integrate the work of their fellows; but few men have within them the combined technical and human resources necessary to administer a great combined effort.

Such men (our executives) must perform a double-barreled task. Theirs is the dual problem of, on one hand, meeting competition by all approved standards, and on the other hand, setting up and carrying out a pattern of human workaday relationships designed to promote efficiency. The prospect in large organizations is truly a man-sized job. The making of decisions, particularly far-reaching scientific, financial, and human decisions is a taxing business—one calling for mental, moral, and physical ruggedness. It is not every man who is endowed with these qualities. He must be a strong man in every sense of the word—a man who will never lose sight of a set objective. Above all, he must be a man who never loses the common touch.

It has been stated that about eighty per cent of all employees are comparatively well. To keep them well and from becoming the so-called problem employees it is important to maintain a clear and unfettered line of communication through all the echelons of management. Grievances, rumors, and bickering can seldom survive the clear light of communication, which rests on the willingness for frank and free discussion.

It is imperative that at some point in the organization there be an impartial listening post to unblock the human communication system should it become snarled. However it is constituted, it must be composed of individuals with sufficient authority to carry grievances to the proper level for a fair hearing, and above all, that the employee be given assurance that this is being done.

There is no quick Utopia as it relates to the employee and his problems, since there are as many as there are employees. But there is a teamwork approach to the matter. An intelligent understanding from top management and a co-ordinated effort on the part of industrial medicine and responsible personnel officials are essential. This is not easy of achievement because it involves an elasticity of view on the part of everyone. And in the final analysis they themselves may be employees with ambition and problems.

Evaluating Basic Materials for
Nuclear-Fueled Power Plants

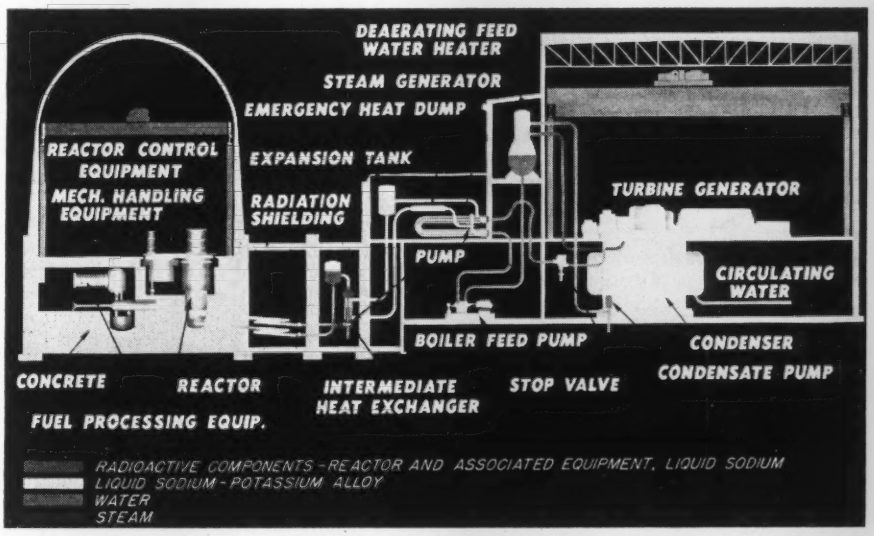

Fig. 1 Arrangement for a steam-power plant utilizing heat energy from a nuclear reactor

The evolution of economical nuclear power plants demands the highest engineering skills in the fields of heat transfer, fluid flow, stress analysis, metallurgy, corrosion, and mechanical design. Since the unique problems center around the reactor itself, a significant portion of the work is fairly conventional. The problem is one of bridging the gap between basic nuclear theories and economical applications.

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REACTORS which are fueled with enriched uranium, or U-235, have been constructed and operated. However, converting the concentrated heat potential of this fuel into superheated steam, which in turn produces power, requires a complex plant. Included in the requirements for a plant, such as shown in Fig. 1, are the primary and secondary cooling systems, specially designed heat exchangers, critical and accurate control mechanisms, and built-in remote-handling facilities. Fortunately, there has not been any dearth of designs of nuclear reactors technically capable of producing electrical power. The problem has become one of balancing economic aspects with technical and design specifications.

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Range of Reactor Materials

The different materials for various purposes contained in a nuclear reactor include the fuel and fertile materials, moderators and reflectors, reactor structural members, fuel canning or cladding, reactor shielding and controls, and effective coolants. Difficulty in selecting these materials is compounded by operating conditions which vary over a wide range of temperature, pressure, electrical-power level, and neutron-flux intensity. Quantities of materials in the reactor core must be controlled carefully because the variation of material quantities could cause a reactivity unbalance. The amount of moderator and coolant, as well as the amounts and design of fuel materials and structural parts, are important factors in the neutron and heat balance in the reactor.

The successful solution of each technical problem necessitates the selection of materials with adequate mechanical, physical, and nuclear-property characteristics. Materials must be capable of being formed and/or joined, and the strength at operating temperatures must be within design limits. Thermal conductivities and heat-transfer coefficients must be high. Expansion

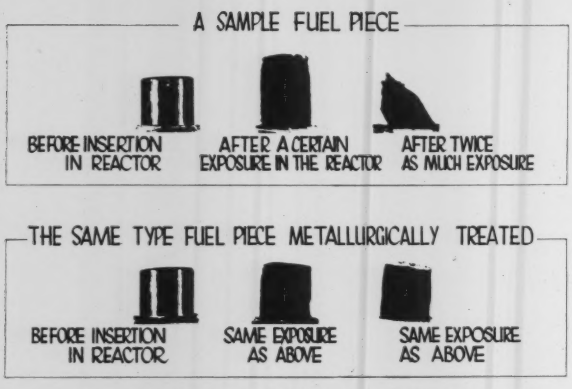
A SAMPLE FUEL PIECE
BEFORE INSERTION IN REACTOR
AFTER A CERTAIN EXPOSURE IN THE REACTOR
AFTER TWICE AS MUCH EXPOSURE
THE SAME TYPE FUEL PIECE METALLURGICALLY TREATED
BEFORE INSERTION IN REACTOR
SAME EXPOSURE AS ABOVE
SAME EXPOSURE AS ABOVE

Fig. 2 Some physical changes in a fuel piece which may occur as a result of radiation in a reactor

coefficients of mated materials should be compatible. Thermal and hydraulic properties of coolant fluids must be satisfactory, and corrosion rates must be within acceptable limits.

While these and other standards are to be met, materials of suitable nuclear characteristics must be used. In the nuclear reactor, the materials in the chain-reacting system must not parasitically capture an excessive number of neutrons. A proportion of the neutrons produced by the fission of uranium atoms must be available to continue the fissioning process. Many materials that do not contribute to the fission process absorb neutrons and emit gamma rays that do not enter into the production of neutrons.

Core and Control Materials

Nuclear Fuels. The fuel is contained in a removable section of the reactor called the core. Here the major portion of the total reactor heat is generated. The quantity of fissionable material in the core must be sufficient to sustain the chain reaction continuously, to provide an excess amount to compensate for fuel burn-up, and to provide an excess reactivity to permit start-up at any time.

Possible fuel materials include uranium, thorium, and plutonium. U-235 is the only naturally occurring fissionable material or fuel, and less than 1 per cent U-235 occurs in natural uranium. U-238 and Th-232, which are source or fertile materials, may be converted into U-239 and Th-233, and then into the fissionable materials Pu-239 and U-233. The process involves absorption of neutrons generated during the chain reaction, and then normal radioactive decay to the desired product.

Natural uranium is a very dense material, $1^1/_2$ times heavier than lead. It has a fairly high thermal conductivity, approximately 15 Btu/hr-sq ft-deg F/ft, and may be used in metallic form. The physical form used in specific circumstances depends upon (*a*) the size of the unit, (*b*) the properties required of the fuel, (*c*) the convenience of handling, and (*d*) the shape desired. This last criterion in turn depends on the fact that many physical changes occur on irradiation.

By using natural uranium enriched in U-235 content, the designer is required to compute minimum fuel charges. Engineering design of fuel elements for a particular reactor must strive toward minimum amounts of uranium and enrichment levels. Criteria for minimum amounts include self-maintenance of the chain reaction, and reasonably uniform heat generation.

Moderator and Reflector. A moderator is a low-atomic-weight material placed in a thermal reactor to slow down the neutrons to thermal energies. The use of slow neutrons enhances a chain reaction in natural uranium since fissionable material absorbs slow neutrons more readily than fast neutrons. When no moderator is used, the chain reaction is maintained by fast-neutron-induced fissions and the reactor is called a fast reactor.

The reflector surrounding the fuel section prevents escape of much-needed neutrons by "bouncing back" a large fraction of the neutrons to the core.

Moderator and reflector materials must be particularly free of thermal-neutron-absorbing elements such as boron, lithium, cadmium, and cobalt. The best moderating and reflecting elements are hydrogen and deuterium, followed by beryllium and carbon.

Ordinary water, which contains hydrogen, is cheap and readily available. Heavy water, which contains deuterium, is superior but is costly and difficult to manufacture. Either type of water must be pressurized to prevent its low boiling temperature from being a limiting factor.

Although costly, beryllium and beryllium oxide have excellent corrosion resistance to pure water. Metallic beryllium is usually brittle up to temperatures of 400 F but above this temperature level it is ductile and can be worked. This metal is comparatively resistant to oxidation up to 1100 F; at higher temperatures, and when molten, it oxidizes rapidly. Beryllium also can be used in a reactor as the compound BeO, known as beryllia. This is a ceramic with a very high melting point—approximately 4450 F. It must be noted, however, that both caution and care must be exercised in using beryllium. The metal and its compound may be poisonous when inhaled and ingested in even small amounts.

Graphite, a form of carbon which can withstand elevated temperatures, 1500 F, is now being produced with extreme purity on a very large scale.

Control and Shielding. The fuel supply for a reactor is completely contained within the reactor core. Since solid fissionable fuel cannot be fed into a reactor and consumed as supplied, the necessary quantity of fissionable material must be in place initially. There is, then, a concentration of a supercritical mass of fissionable material within a small volume that requires the use of high-neutron-absorbing materials to guarantee safe and controlled operation.

Safe and stable reactivity control of the power level is maintained by absorbing, in control rods, a necessary portion of the neutrons being produced. The rods must have adequate structural strength, resistance to radiation damage, high thermal conductivity, and a high neutron-capture probability. For thermal reactors, materials with high neutron cross sections, such as cadmium and boron, are used. In a fast reactor, all materials have relatively low cross sections so the problem becomes one of design as well as material selection.

The shielding section is provided to insure the attenuation of hazardous neutron and gamma radiations to a safe external level and is usually divided into two parts with separate functions. One is the thermal shield to slow down the fast neutrons and to absorb, partially at least, the thermal neutrons and gamma rays. The other part is the biological shield which reduces the escaped or

Table 1 Slow Neutron Absorption by Structural Materials

Material	Relative neutron absorption per $cm^3 \times 10^3$	Relative neutron absorption for pipes of equal strength (20 C)	Melting point, deg F
Magnesium...	3.5	10	1200
Aluminum....	13	102	1230
Stainless steel.	226	234	2730
Zirconium....	12.6	16	3330

Table 2 Slow Neutron Absorption Cross Sections

Low		Intermediate		High	
Element	Cross section, barns	Element	Cross section, barns	Element	Cross section, barns
O	0.0016	Zn	1.0	Mn	12
C	0.0045	Nb	1.2	W	18
Be	0.009	Ba	1.2	Ta	21
F	0.01	Sr	1.3	Cl	32
Bi	0.015	N	1.7	Co	35
Mg	0.07	K	2.0	Ag	60
Si	0.1	Ge	2.3	Li	67
P	0.15	Fe	2.4	Au	95
Zr	0.18	Mo	2.4	Hf	100
Pb	0.18	Ga	2.8	Hg	340
Al	0.22	Cr	2.9	Ir	470
H	0.32	Tl	3.3	B	715
Ca	0.42	Cu	3.6	Cd	3000
Na	0.48	Ni	4.5	Sm	8000
S	0.49	Te	4.5	Gd	36000
Sn	0.6	V	4.8		
		Sb	5.3		
		Ti	5.8		

reproduced neutrons and gamma rays to tolerable levels for humans. Lead, tungsten, tantalum, or iron combined in some form or another with moderating materials such as boron, water, or concrete make good radiation shields.

Auxiliary-System Materials

Successful operation of a nuclear reactor depends on the proper choice of materials used in (1) the operating mechanisms and plant structure, (2) the cladding or canning of solid fuel, and (3) the sensing and instrumentation units. A reactor with only the chain-reacting fuel cannot be controlled successfully; therefore operating mechanisms and auxiliary structures are included in the design. Operating mechanisms, usually actuated by controlled servo devices, require the use of suitable materials for gears, bearings, control rods, springs, instruments, electrical connectors, and the like. The auxiliary structures and plant include materials for pressure vessels and closures, valves, piping, pumps, welded components, and other related equipment.

Structure, Cladding, and Instrumentation. Table 1 lists some structural and cladding materials which have been or could be used in reactors. Although mechanical and physical properties of contemplated structural materials are important, their position and effect on the reactor must be considered.

One reason that uranium fuel elements are protected by a coating or cladding is that bare uranium is chemically active. It is corroded by air and water at room temperatures. Cladding-material requirements include not only reasonable cost and strength but also low neutron cross sections and high thermal conductivity. Some idea of the relative cross sections of potentially useful materials for reactors can be gained from Table 2. The slow-neutron-absorption cross sections are given for the common elements, and from these values the cross sections of alloys can be calculated.

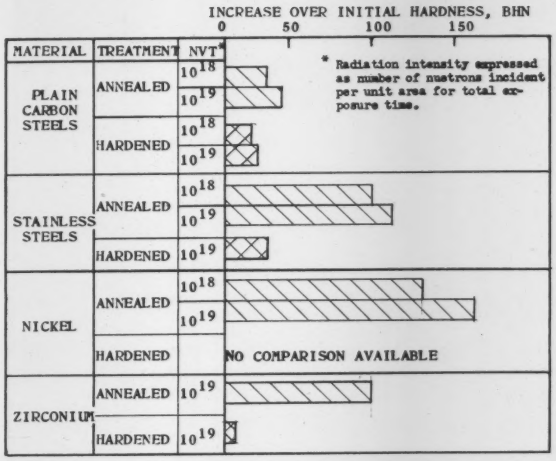

Fig. 3 Effect of irradiation dosage on the hardness properties of structural materials.

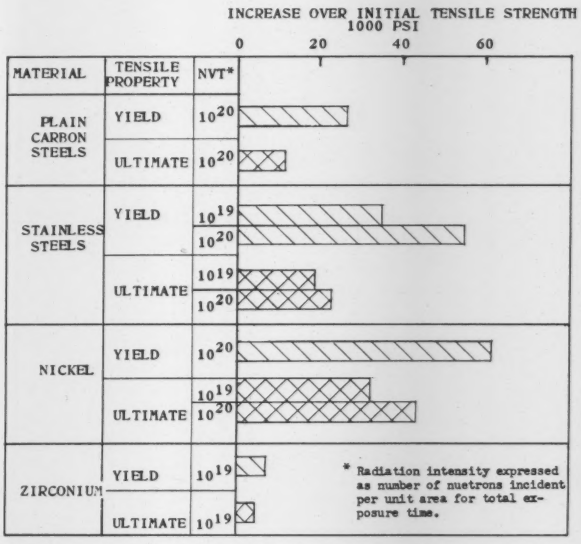

Fig. 4 Effect of irradiation on tensile properties of structural materials used in reactors.

It should also be realized that the operation of a reactor imposes unusual conditions on materials of construction. One such condition is the effect of irradiation produced when a charged particle of high velocity collides with the nuclei of atoms in its path. Mechanical and physical properties of materials may be altered by cold work and also are known to be affected by irradiation. Figs. 3 and 4 show the effect of irradiation dosage on the hardness and tensile properties of reactor structural materials.

Presence of a small percentage of random disturbances may result in large change in properties, changes being proportional to the fraction of displaced atoms.

Problems also arise in the selection of materials which must convey a signal sensitive enough, even under the effects of irradiation, to provide close instrument control over a wide range of temperatures. Unlike the conditions

in conventional boiler rooms, reactor operating personnel are not in a position to see, hear, or feel changes in reactor conditions. They operate in shielded control rooms and rely on sensing instruments for operational information.

There is little doubt that carbon steels, stainless steels, and nonferrous alloys of zirconium, cobalt, and nickel will constitute a large portion of the auxiliary-system materials in presently anticipated power reactors. Since steel imposes a severe penalty on the reactor because of its large parasitic capture of neutrons, it is used sparingly near the core.

Heat-Transfer Materials

Coolant and Corrosion. Special attention should be given to coolants and their corresponding influence on corrosion. The heat-generating reactor core requires some medium to transfer the heat from the core to other regions for its use in converting water to steam. In a specific reactor, heat densities are very high and heat removal must be very efficient. At the same time, the transport of radioactivity through the entire power system must be kept at a minimum.

The sources of radioactivity in the cooling system are induced and direct. Induced activity in the coolant results from the neutron absorption by both the coolant and by the corrosion products in the coolant stream. Fission products may enter the system directly as a result of fuel-element cladding failure. There is little that can be done to prevent the induced activity in the coolant, since all materials exposed to radiation become radioactive to some extent. Fission products can be minimized by effective fuel cladding; corrosion products can be limited by the use of relatively corrosion-resistant materials. Although induced activity of the coolant is permissible if shielding is used, serious damage stems from the radioactive corrosion products and fission products finding their way into the coolant and being deposited on system components. Deposition of these corrosion and fission products interferes with the efficiency of the heat-source and heat-transfer surfaces and requires special precautions during maintenance.

For these reasons, then, the selection of a coolant must necessarily include the requirements of relatively low neutron-absorption characteristics and low corrosion rates on container materials. This last requirement is particularly important since corrosion rates usually increase with increased temperature.

Since it is difficult to predict where the transported radioactive products will deposit, all reactor coolant systems must be designed for minimum leakage. In special reactor types, where steam is taken directly from the reactor to the turbine, extra care must be observed to reduce the leakage from pipes and turbines. The need for low corrosion rates to insure integrity of piping that separates liquid metal and water in heat-transfer systems will be recognized readily. Mixtures of these liquids are usually violent and may even be explosive.

In comparing likely coolants, the final choice is made on the basis of advantages for the type system under consideration. A comparison of the relative advantages and disadvantages of some coolants follows. Both light and heavy water have the advantages of high heat capacity, and low neutron cross sections. However, both are poor with respect to corrosion and vapor pressures—they are actively corrosive and their high vapor pressures require heavy and expensive equipment. Sodium has the advantage of low pressures at high temperatures, high boiling point, and high average heat fluxes, and is relatively inactive corrosionwise. Nevertheless, it is very reactive with oxygen and water, freezes at about 200 F, and its induced-activity potential is high and relatively long-lived.

Fabricating Aspects

The job of designing, constructing, and controlling nuclear reactors is only part of the engineer's task. Included are the development of fuel elements and the recovery of the fissionable fuel from spent elements. Since all fissionable fuels are toxic, a foolproof remote-control system for the removal and reprocessing of intensely radioactive spent fuels is required. These materials give off alpha particles with various energies that produce harm to the body in proportion to the particle concentration in the body.

All machining work on fissionable materials is performed in isolated boxes or in extremely well-ventilated hoods. This equipment not only protects the worker but also permits recovery of chips, turnings, and oxides from fuel materials right at the machine. The hoods are made so that a coolant or liquid vehicle carries all excess machinings into a pan and not on the working surfaces. Contaminated air and coolant are withdrawn from the hood, separated, and individually filtered.

The actual techniques of working uranium are standard fabrication processes modified to meet requirements imposed when handling radioactive materials remotely. Uranium can be machined; however, it oxidizes rapidly. When finely powdered, it is highly flammable and its fires are capable of contaminating large working areas. Because of its reactivity with many gases, the melting of uranium must be done in vacuum, in an inert atmosphere, or under a flux of molten salt not reactive to gases. Its melting temperature (approximately 2000 F), combined with its corrosive nature when molten, requires the use of high-temperature ceramic containers and special mold materials during melting and casting.

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Uniform Notation System for Pressure-Vessel Shell Theory

The Pressure Vessel Research Committee of the Welding Research Council was created in 1945, under the general organization of the Engineering Foundation to encourage, promote, and conduct needed research in the pressure-vessel field, including consideration of problems of materials, design, and fabrication. The Main Committee of PVRC consists of about 100 representatives of fabricators and users of pressure vessels, materials suppliers, research organizations, insurance companies, and codemaking bodies. The ASME Boiler and Pressure Vessel Committee is represented by its Chairman, H. C. Boardman, past-chairman, H. B. Oatley, Secretary, J. D. Wilding, and several other members. A Subcommittee on Uniform Notation consisting of D. K. Davies, Chairman, R. L. Graves, and C. E. Taylor was established by the Design Division of the Pressure Vessel Research Committee in 1953 to study the need for a standardized nomenclature system in the field of pressure-vessel design. The original proposals of the Subcommittee were submitted for recommendations and comment to a large number of authorities in this field and the related branches of structural mechanics, and this final paper presents the results of extensive discussion and revision.

In an effort to establish a standard notation system for pressure-vessel shell theory, the Design Division of the Pressure Vessel Research Committee, in 1953, established a subcommittee to study and report on this problem. The following notation is the result of two years of study by this subcommittee, which was given valuable aid from contributions by PVRC members and other interested parties.

The intent of the subcommittee was to standardize pressure-vessel shell nomenclature in order to make it easier to read material on shell theory and to facilitate communication between independent investigators.

In the study, an effort was made to utilize, in so far as was possible, nomenclature which has been in common usage and with which most engineers are currently familiar. It was found impossible, however, to utilize completely any existing notation system since no such system appeared to have sufficient scope.

It is recognized that some individuals will disagree with this system in certain particulars but it is the feeling of the committee that the system represents a reasonable compromise between the demands of theoretical and practical extremes.

In certain instances, it may be necessary to modify this notation to cover special shapes. For example, certain definitions and sign conventions, which may need further explanation in the case of a torus, can better be given in a specific context.

It will be noted that symbols have been included in the notation for a right circular cylinder for certain quantities associated with special types of loading which have not been included in the general shell notation. This has arisen from wider interest in the effects of special loads on cylindrical shells. Furthermore, it should be understood clearly that, in the interest of clarity and brevity, no attempt has been made to provide for all possible types of loading for either the general shell or the right circular cylinder.

Prepared by Subcommittee on Uniform Notation of the Pressure Vessel Research Committee of the Welding Research Council.

General Definitions

Shell of Revolution. Surface generated by the revolution of a curve about an axis. (In particular cases it is convenient to substitute "head" or "cylinder" for "shell.")

Given a shell of revolution and a point on its unstrained middle surface, define planes as follows:

Meridional Plane. The plane passing through the axis of the shell and the point.

Latitudinal Plane. The plane perpendicular to the axis of the shell and passing through the point.

Tangent Plane. The plane tangent to the midsurface of the shell at the point.

Normal Plane. The plane perpendicular to both the meridional and tangent planes and passing through the point.

With this point, the following quantities are associated (see Fig. 1):

R_N—normal mean radius, radius of curvature of middle surface of shell section in normal plane, inches

R_M—meridional mean radius of curvature of middle surface of shell section in meridional plane, inches

R_L—latitudinal mean radius, radius of curvature of middle surface of shell section in latitudinal plane, inches

r—radial co-ordinate, inches

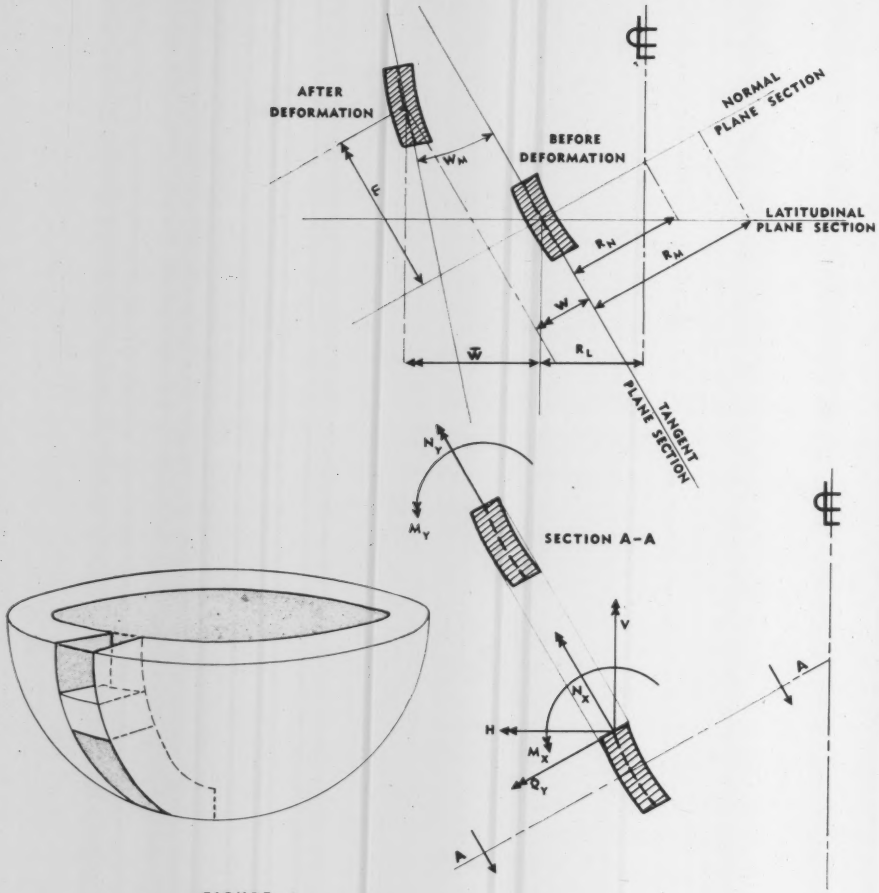


FIGURE 1

NOTE: ⟵ DENOTES POSITIVE DIRECTION

x—variable distance along middle surface of shell in meridional plane measured from some reference point, inches

y—variable distance along middle surface of shell in latitudinal plane measured from some reference point, inches

ϕ—angle between normal to shell middle surface and shell axis in meridional plane, radians

θ—angle in latitudinal plane between meridional plane and reference meridional plane, radians

z—variable distance from middle surface of shell normal to middle surface (positive away from shell axis), inches

u—longitudinal displacement, displacement (component) in intersection of meridional and tangent planes, inches, in direction of x

v—circumferential displacement, displacement (component) in intersection of latitudinal (or normal) and tangent planes, inches, in direction of y (positive when it increases distance of point from a reference meridional plane)

w—radial displacement, displacement (component) in intersection of meridional and normal planes, inches, in direction of z

$\bar{w}$—displacement normal to axis, displacement (component) in intersection of meridional and latitudinal planes, inches
(Note: displacement components are positive when they increase the distance of the point from the shell axis)

K—change in curvature (use subscript N, M, or L to denote specific item), positive when it tends to put outside of shell in compression, inches

W—rotation, change of angle of tangent line to middle surface (use subscript N, M, or L, etc.) (sign convention to be established for particular case)

ϵ_x—axial strain, strain in direction of x, inches per inch

ϵ_y—circumferential strain strain in direction of y, inches per inch

ϵ_z—radial strain, strain in direction of z, inches per inch

N_x—axial force in direction of x, pounds per inch

N_y—circumferential force in direction of y, pounds per inch

N_z—force, in direction of R_M, pounds per inch

H—force resultant normal to axis, in meridional plane, pounds per inch

V—force resultant parallel to shell axis, pounds per inch

Q_y—radial shear, shear in direction of R_M on section in direction of y, pounds per inch

M_x—axial moment, moment on element in direction of y and acting in meridional plane, inch-pounds per inch

M_y—circumferential moment, moment on element in direction of x and acting in normal plane, inch-pounds per inch.
(Note: Moments which tend to put the outer surface of the shell in compression are positive.)

t—thickness of head or shell, inches (may be variable)

E—modulus of elasticity, psi

ν—Poisson's ratio

G—shear modulus equals $E/2\ (1 + \nu)$, psi

D—$Et^3/12(1 - \nu^2)$, inch-pounds

$$\lambda^4 = \frac{3(1 - \nu^2)R_M{}^4}{R_N{}^2 t^2}$$

p—pressure acting on middle surface of shell, normal to middle surface (positive when acting away from shell axis), psi. It is necessary to modify this definition for thick-shell theory

dot or prime—derivative with respect to independent variable

d—diameter of opening in shell, inches

For the thin, right circular cylindrical shell illustrated in Fig. 2 the following nomenclature is used:

R—mean radius of cylindrical shell, inches

L—length of cylindrical shell, inches

t—shell thickness, inches

x—axial co-ordinate, inches

y—circumferential co-ordinate, inches

z—variable distance from middle surface of cylinder normal to middle surface (positive away from cylinder axis)

r—radial co-ordinate (positive outward), inches

θ—angle in latitudinal (normal) plane between normal to cylinder middle surface and a reference normal, radians

u—longitudinal displacement, component, inches

v—circumferential displacement, component, inches

w—radial displacement component (positive away from axis), inches

ϵ_x—normal strain in axial direction (+ denotes tension), inches per inch

ϵ_y—normal strain in circumferential direction, inches per inch

ϵ_z—normal strain in radial direction, inches per inch

γ_{xy}—shear strain in middle surface, inches per inch

W_y—rotation, change of angle of tangent to shell in latitudinal plane, radians (sign convention to be established for particular case)

K—change in curvature (positive when it tends to put outside of cylinder in compression)

W_{xy}—twist of middle surface, radians

N_x or V—normal force per unit length in axial direction (positive when tension), pounds per inch

N_y—normal force per unit length in circumferential direction, pounds per inch

N_{xy}—shear force per unit length on elements cut by generators, pounds per inch

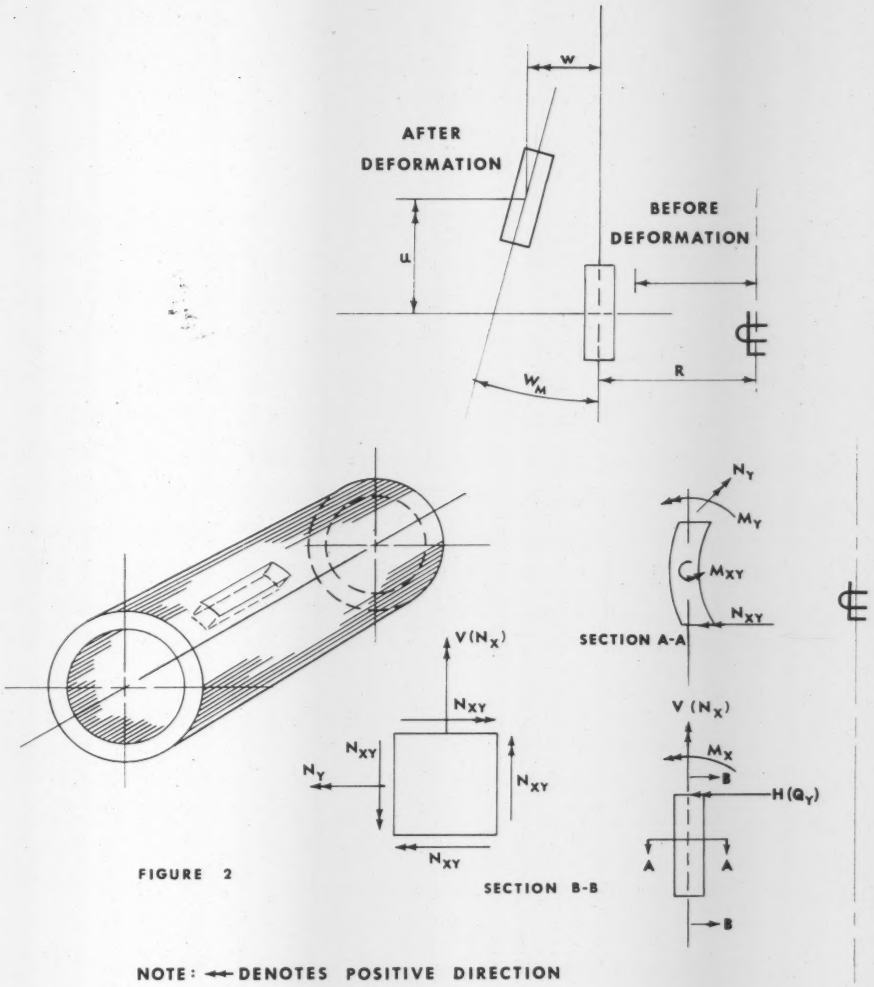


FIGURE 2

NOTE: ← DENOTES POSITIVE DIRECTION

M_x—axial bending moment per unit of circumference, inch-pounds per inch

M_y—circumferential bending moment per unit length, inch-pounds per inch

Q_x—radial shear on section in direction of x, pounds per inch

Q_y or H—radial shear on section in direction of y, pounds per inch

M_{xy}—twisting moment per unit length on element cut out by generators, inch-pounds per inch

σ_x—normal stress in axial direction (+ denotes tension), psi

σ_y—normal stress in circumferential direction, psi

τ_{xy}—shear stress on element cut out by generators, psi

p—intensity of uniform pressure acting normal to surface of cylinder at middle surface, psi

E—modulus of elasticity, psi

ν—Poisson's ratio

G—shear modulus equals $E/2\ (1 + \nu)$, psi

$D = Et^3/12\ (1 - \nu^2)$, inch-pounds

$$\beta^4 = \frac{3\ (1 - \nu^2)}{R^2 t^2}$$

Air Pollution . . .

. . . The Growth of Public Opinion

By Sir Hugh E. C. Beaver

Managing Director, Arthur Guinness Son & Company Limited, Park Royal Brewery, London, England

It is particularly appropriate that this, the Calvin W. Rice Lecture, should be devoted to a subject and a problem common to modern industrial and domestic conditions everywhere. In England, the history of the campaign against air pollution goes back more than 700 years. Periodic and violent protests against conditions until recent times had resulted in practically no effective accomplishment. In 1952, the "London Smog," which caused some 4000 deaths, caused a thorough investigation of conditions to be made by a committee over which the author presided. Recommendations of this committee were presented in November, 1954. It is believed that public opinion now has reached the point where both public and industry will accept even the drastic control provisions which have been incorporated to achieve "clean air."

THE campaign against air pollution, at least in England, goes back 700 years. For the most of this time, coal smoke and soot have drawn criticism and attack. While the evil has been described in violent and scathing terms, generation after generation has passed without effective action ever being taken to alleviate the problem.

The Latest Approach

When I assumed the chairmanship of the latest committee on this subject in my country, I soon came to the conclusion that in all probability there could be little new to be said; that thirty or fifty or indeed a hundred years before, the same criticisms and the same or similar recommendations had been made. It could have been a disheartening introduction to our new task to read the concluding paragraphs of the previous committee which reporting 33 years ago, complained, "No Government has for many years taken any action with the exception of appointing committees whose labours have led to little or no result."

But all action to be successful needs to be successfully timed and it may well be that conditions are now ready in my country for really drastic action. That is why it seems worth while to devote this paper to a brief study of the growth of public opinion, for all experience shows that on public opinion, and on it alone, finally rests the issue.

To study the growth of opinion I must sketch the high lights of the story over the centuries in England.

Seven Hundred Years of Inaction

It strikes a sympathetic chord, I think, to learn that seven hundred years ago almost to a year the then Queen of England moved out of the city of Nottingham where she was residing because of the insufferable smoke; and that some 300 years later the brewers of Westminster offered to use wood instead of coal because of Queen Elizabeth's allergy to coal smoke. But it was only about the end of her reign that feeling began to lead to action; and then there was a prohibition—probably ineffective—of the use of coal in London while Parliament was sitting!

Halfway through the next century the citizens of London unavailingly petitioned Parliament against any importation of "sea" coals from Newcastle; and John Evelyn the Diarist produced his famous pamphlet, "Fumifugium," in which he advocated the cure of the London smoke nuisance by removing all the smoke-producing plants out of London.

In the eighteenth century it was appreciated and often emphasized that the trouble from smoke was due to the inefficient use of coal.

First "Smoak" Nuisance Committee

But I think one cannot say that there was any real beginning of public interest until the very end of that century. By 1801, the corporation of Manchester actually had a Nuisance Committee dealing with "Smoak." By 1819, there was sufficient pressure for Parliament to appoint the first of a whole dynasty of committees "to consider how far persons using steam engines and furnaces could work them in a manner less prejudicial to public health and comfort." This committee in due course confirmed the practicability of smoke prevention, as so many succeeding committees were to do; and as was often again to be experienced, nothing was done.

In 1843, there was another Parliamentary Select Committee; and in 1845 a third. In 1855, the General Board of Health published an official review of the smoke problem and of efforts to abate it.

It is necessary to telescope this historical survey and, just mentioning the Public Health Acts of 1866 and

Contributed by the ASME Committee on Air Pollution and presented at the First International Congress on Air Pollution of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, N. Y., March 1–2, 1955. Condensed from ASME paper 55—APC-1.

1875, I come through continuing and increasing smoke to the 80's. In 1881, interested bodies formed The Smoke Abatement Committee, and staged an exhibition in London; The Manchester Noxious Vapours Association had an exhibition the next year. This surge of activity culminated in the introduction into the House of Lords of a Smoke Abatement Bill on behalf of London; but it got nowhere.

Combined agitation of various local authorities throughout the country led to the introduction into Parliament of a Bill at the end of 1913. The Bill was withdrawn on a promise by Government to appoint a committee; and another committee was duly appointed. By this time, however, the first World War was upon us and, though the committee just met, it immediately went into abeyance.

Government Committee Report of 1931

In 1920, the Government Committee of 1914 was revived, under the chairmanship of Lord Newton; it published its final report in December, 1921.

The report occasioned very little interest; but it is to be remembered that we were then in a precarious and dizzy situation economically; it was a period of political struggle; the whole of our industrial prosperity was threatened, and indeed the long period of disastrous slump and unemployment was about to start. Under the circumstances action was neither likely nor perhaps possible. Even so the total absence of general interest is notable. It was evident that nothing very inconvenient or disturbing would flow from the report. And little did until 1936, when a new Public Health Act was passed, of which one part specifically dealt with air pollution.

This is still the prevailing law—an act, in so far as air pollution is concerned, full of loopholes, reservations, and safeguards and more or less licensed default. The view of my Committee regarding this act is given in a sentence:

"It is apparent from the conditions which prevail today that the law has failed to achieve its purpose, notwithstanding that it has been in operation for many years, and that considerable progress has been made in the technique of smoke prevention."

But the campaign continued. One cannot say that it greatly increased in strength, but advance undoubtedly was made. The National Smoke Abatement Society was formed and for the first time this put agitation, propaganda, and public education on a national basis. Manchester, always in the van, invented and secured parliamentary powers for the new idea of smokeless zones (to which I shall refer later).

But before much could be done World War II came upon us, and for a time all the industrial plants were actually encouraged to make as much smoke as possible as a protection against accurate bombing. After the war we subsided back into the old pattern—with some local authorities active. Owing to our worsening fuel situation, increasing emphasis was laid on the fact that smoke meant waste of our diminishing coal resources.

The 1952 Disaster

And then in December, 1952, occurred what in my country has become universally known as the "London Smog"—in its way I imagine the most disastrous, the most lethal occurrence of air pollution that has yet been chronicled. We have always had heavily polluted fogs in London and in some of our other industrial cities. They are seasonal; frost and still air inevitably produce them. Each winter from November to February, some fogs or smogs, generally pretty bad, are certain. But between December 5 and 9, 1952, there was a smog in London which in those four days caused some 4000 deaths.

It was only slowly that the extent of the calamity dawned on either medical authorities or Government or the public. It was not until December 18, that the Minister of Health was able to give reliable although still incomplete figures. At once there was an outcry. The papers with hardly an exception demanded an inquiry. People were unquestionably, and for the first time, frightened, and even a year later when winter fogs again appeared many started to wear masks. I think there is little doubt that the Government was completely undecided how to cope with the matter, and for 6 months nothing was done. Naturally the main clamor in the press quickly died down, but from time to time the matter was revived by one paper or another; and pressure from many individuals continued steadily.

The Committee—which, as so often before, was the answer—and over which I presided was appointed in July, 1953. In November, an interim report was submitted which was received with a howl of derision by most of the popular press. So much the better. Anything was better than absence of interest.

Final Report Issued in 1954

A year later, in November, 1954, we published our final report. It came out at the beginning of our serious fog season. It was received with the most remarkable chorus of approval and a general call for action. This reception cannot be claimed to be the result of anything of special note in the report itself. The report was received as it was, I believe, simply or mainly because the atmosphere of public opinion was at the moment peculiarly suitable and receptive for the right kind of report. We on the committee cannot claim credit for any mastery of timing; but perhaps we can claim to have recognized the time.

In preparing the report we adopted a perhaps unusual technique in regard to the taking of evidence and collecting of facts. We took no formal evidence. We started with the premise that all persons and all parties were agreed as to the objective, namely, the cure of air pollution, and that the only questions for discussion therefore were the practicability and the means. We invited in turn all interests to a sort of round-table discussion of a joint problem; and we broke up our committee into a number of small subcommittees to carry on the subsequent discussions quite informally. We believed—and the event confirmed the belief—that circumstances justified such an approach and that far better results would be secured.

What the Report Covered

We started our report by a clear statement of the two counts against air pollution—health and cost. We expressly avoided basing our arguments on the danger to health of particular incidents, such as the London Smog of 1952. Not that we minimized that catastrophe in any way, but we felt that undue emphasis on it would

distract attention from the fact that damage to health and danger to life were going on all over the country, all the time, year in and year out. It was inevitably a black and disquieting picture; a sad bill of unhappiness and ill health and earlier death that the whole country was paying. And then we gave our considered estimate—and I think we went further into this problem than had previously been done—of the economic cost to the nation.

Over and above the burden of ill-health, the country was spending per year directly and indirectly because of air pollution something like five pounds, say, fifteen dollars per head of the population. This was our, as we believe, conservative estimate. It was against this whole background that we then proceeded to make our recommendations. I suppose someone might feel that we could have been more scientific in our presentation of the case. I would claim that we were absolutely judicial, but when it came to sentence we were the hanging judge; and after all we were dealing with human beings and their living conditions.

Extent of Problem

It will be recalled that England, Scotland, and Wales comprise in all some 88,000 sq miles and have a population of about 51,000,000 persons. Eliminating all the northern and far western parts of Scotland, the hills of Wales and the extreme southwest of Devon and Cornwall, there is an area of, say, 60,000 square miles in which almost the whole of the population lives—say, the area of the State of Michigan and 8 times its population. Large parts of this area are highly industrialized and obviously very closely populated. Except in the south no part would be more than about 100 miles wide, often not that; there are in this area some 14,000,000 houses nearly all with open fireplaces and some hundred thousand factory chimneys. If one includes all the small furnaces which between them may consume some 10 to 15 million tons of fuel a year, the total number of chimneys would be at least twice as great and possibly more. Add that pollution from factory chimneys and domestic grates has been measured 60 and more miles from its source, and one has some idea of the problem, namely, one single permanently polluted area.

My committee moreover estimated that more than half the population lived in highly industrialized and heavily populated areas that were by geographical situation subject to frequent and persistent natural fog throughout the autumn months and consequently subject to frequent concentrated severe smog. We called these the "black areas," and we decided that attention in the first instance must be directed to these plague spots.

Proposals

First, we proposed that all previous legislation, national and local should as it were be swept up into a new all-embracing act applicable to the whole country. We proposed that this new act should be called the Clean Air Act, a simple but, as I feel, brilliant and pregnant suggestion that came to us from our subcommittee dealing with legislation over which presided Sir Roger Duncalfe, also the Deputy Chairman of the main committee.

We proposed that legislation regarding industry should be nationwide and that there should be no question of pushing or removing potential industrial nuisances out of one local boundary into another.

We proposed that in so far as all ordinary furnaces are concerned dark smoke is prohibited and that it no longer should be necessary to prove nuisance. We proposed that there should be no "protected" or sheltered industries or processes; that all without exception should be subject to challenge by really qualified national inspectors.

We proposed to create a simple way of establishing "smokeless zones," instead of each local authority having to secure parliamentary power for itself.

We invented a new type of semismokeless zone in which smoke was to be reduced by 80 per cent and which, therefore, could include a large amount of industrialized area, which could not be fitted into any smokeless zone.

The smokeless zone aims at absolute smokelessness; and since low-volatile coals in England are scarce, gas and electrical heating costly and all oil is imported, it is obvious that even the utmost practical development of smokeless zones could only solve a small part of the smoke problem. We therefore devised a type of area, which we called "Smoke Control Areas," where we aimed at an 80 per cent over-all reduction of the total smoke. This would be within the reach of all industrial plants, except those of special and particularly difficult processes. By this means, effective smoke reduction would be secured over a very large part of the industrial and populated areas. Under our proposals all local authorities would be given legal powers, subject to ministerial approval, to establish smokeless and smoke-control zones.

We proposed that part of the costs that would fall on individuals and businesses should properly be defrayed from the national purpose.

We proposed that every local authority would have to publish annually an account of its activities in the past year in dealing with air pollution.

Finally we proposed that there should be established a Clean Air Council to watch, to encourage, to co-ordinate all activities and all aspects; and to report annually to Parliament.

Awaiting Results

Twenty or even five years ago, recommendations of the nature reported would not have had the slightest chance of acceptance by Government, industry, or the average householder. The growth of public opinion, however, has created a new atmosphere in which the odds are quite strong that action will follow. What emerges from the situation is that, formerly, propaganda and education have been too fragmentary and haphazard, too little concerted and sustained. While public opinion, even in the best of causes, takes its own time to reach the boiling point, consistence and common sense are both essential in any campaign to appeal to the common man. This is our approach and we recommend it to those engaged in the battle for clean air.

Heat-Transfer Applications in the Human Body . . . .

Well-being and efficiency under widely varying temperature conditions being studied for use by industry and the military establishment

By C. L. Taylor

Professor of Engineering, Department of Engineering, University of California, Los Angeles, Calif.

THE investigation of man's response to thermal exposures leads one not only into fields of fundamental biological and biophysical science, but also into areas of application to industry, to climatic adaptation, and to military operations. Interest in the broad topic is shared by physiologists, biophysicists, and environment engineers. Study begins with the physics of heat transfer represented in interactions between man and his natural or artificial environment. The resultant bodily thermal state, whether one of adjustment or breakdown, must be understood in terms of basic processes in the body which seek adaptation, in part by shifting the thermal balance, and in part by accepting a moderate change in body temperature.

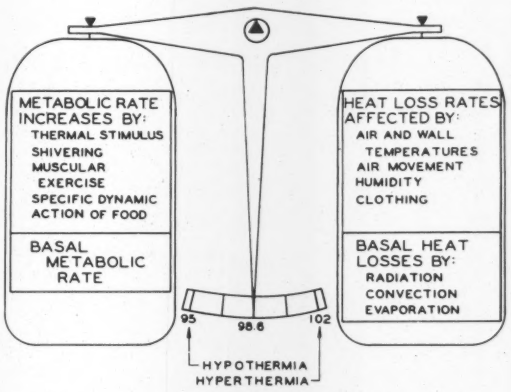


Fig. 1 Human heat balance showing a simple representation of the equality between internal heat sources and losses through the skin and clothing under the usual circumstance that the environment is cooler than the body surface

The Human Heat-Exchange Process

The exchange of heat between the body and its environment is so regulated as to preserve almost constant deep body temperature. The processes concerned in this regulation are both biophysical and physiological. Fig. 1 presents the elements of the heat balance in schematic fashion.

Condensed from an address presented at the Heat Transfer Division Luncheon, at the Annual Meeting, New York, N. Y., November 28–December 3, 1954, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

Metabolic Rate and Work. Internal (or metabolic) heat production is a function of many physiological conditions and stimuli but the principal controlling factor is the level of activity. It is obvious that as metabolic rate is elevated through activity, a large part of the task of heat regulation will be to transfer this heat outward to the skin and to convey it away by the heat-loss mechanisms.

Modes of Heat Exchange With Environment. From a purely physical point of view, the human body can be considered to be a warm body of irregular geometry, behaving approximately as a Planckian radiator, and having varying moistness of surface. The equations for radiant, convective, and evaporative heat-transfer rates are of familiar and conventional form, and introduce no basically new concepts. However, coefficients must be evaluated experimentally, and, although many measurements have been made, it cannot be said that a full quantitative formulation has yet been achieved. Therefore, because of the complex of interacting factors, maximum dependence must be placed upon experimental studies, in which both sweat rate and evaporation rate are separately determined.

Physiological Regulation of Thermal Exchanges

It would be easy to accept the oversimplified view that the body is a warm moist object carrying out heat exchanges with its physical environment in an inert manner. Nothing could be farther from the truth, and the possession of a body-temperature-regulation system is one of the important evolutionary acquisitions of man. This system is capable of varying the internal-heat production, the heat conduction within the body, the skin temperature, and the sweat output, to preserve a near constancy of deep body temperature. The central mechanisms of control may, in very elementary terms, be compared to a dual thermostatic control which activates both heater and cooling units. Its setting is about 98.6 F in resting and mild-activity conditions, but apparently shifts to about 102 F in heavy exercise. The "thermostat" is, in fact, a nerve center or centers within the brain, controlled by nervous sensing elements which react both to central blood temperature and to body-surface temperature. Effector nerves actuate skin blood-vessel constrictor-dilator responses, sweat-gland output, shivering, and so on, to bring about the indicated correction of body thermal state.

Various temperature functions come into play when high thermal stresses are placed upon the body. Shiver-

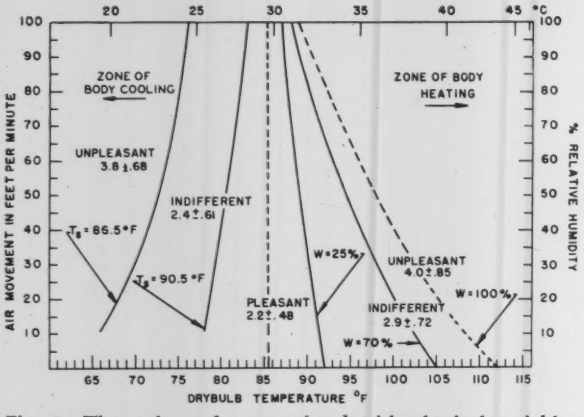


Fig. 2 Thermal comfort correlated with physical variables showing comfort in cool conditions (left half) as related to air movement and skin temperature, in warm conditions (right half) as related to fraction of wetted area and relative humidity

ing occurs when mean body temperature is depressed about 2 deg F below the "neutral" condition of deep and skin temperatures of 98.6 F and 92 F, respectively. As a result, metabolic rate is increased in an attempt to supply cooling demand with greater heat flow and thus preserve the body temperature. At high combinations of temperature and humidity, a general increase of heart output and blood circulation strives vainly to convey heat to the surface, and thereby to ameliorate the thermal stress. Beyond the effective limits of body-temperature regulation, the symptoms of thermal breakdown occur.

The Thermal "Steady States"

Actually, the human body does not exhibit a precisely steady state in any of its processes, and the biological usage of the term is of limited validity. In thermal matters, therefore, one must be content with a relative approach to the steady state. Still, the relative success of the compensatory processes is the striking feature, as compared to conditions which terminate in frank hyper or hypothermia.

The Zone of Thermal "Neutrality" and Relative Comfort. A large amount of investigation has been made by psychologists, physiologists, and engineers to define the temperature, humidity, and air-movement conditions under which persons are thermally comfortable. It is evident that the results of such studies provide specifications for heating, ventilating, and air-conditioning practice.

Over a period of thirty years the ASHVE laboratory has made important contributions to this subject, and the "Effective Temperature Scale and Comfort Zones"[1] have become the standards of practice in the United States and many other parts of the world. A different but analogous portrayal of the interrelationship between comfort reports, physiological measures, and environmental variables is given in Fig. 2 by Herrington and Hardy.[2]

[1] "Heating, Ventilating, and Air Conditioning Guide," American Society of Heating and Ventilating Engineers, New York, N. Y., 1955.

[2] "Temperature and Humidity in Relation to the Thermal Interchange Between the Human Body and the Environment," by L. P. Herrington and J. D. Hardy, Human Factors in Undersea Warfare, National Research Council, Washington, D. C., 1949.

States of Compensated Hyper and Hypothermia. Under heating and cooling loads of considerable magnitude, the body achieves a near-steady state of temperature, lasting for hours. The thermal state ranges far beyond the conditions for comfort, but the body temperatures, whether low (hypothermia) or high (hyperthermia), are kept at fairly constant level and compensation may be said to be achieved. The environmental and activity conditions under which these thermal states occur are difficult to define precisely, since clothing, health, acclimatization, etc., are additional modifiers. Fig. 3 places these states within a "zone of physiological

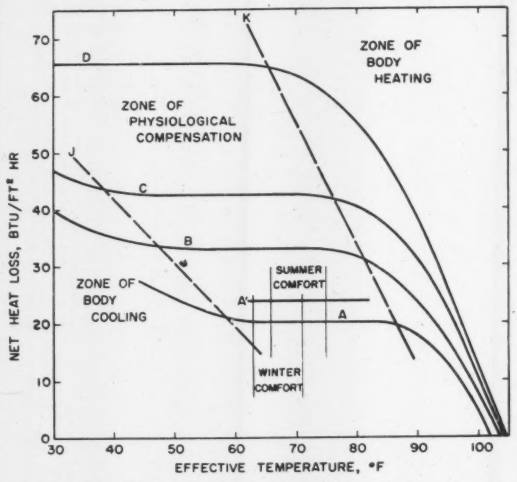


Fig. 3 Comfort and tolerance chart for rest and work conditions. Activity levels are: A, sitting at rest, 20 Btu/sq ft hr; A′, manual work, sitting, 24 Btu/sq ft hr; B, light work, standing, 33 Btu/sq ft hr; C, moderate work, 42.5 Btu/sq ft hr; D, hard work, 65.5 Btu/sq ft hr. Net heat loss = $q_m + q_s$ (adapted from reference, footnote 1).

compensation." Beyond this are the transient zones of body heating and body cooling.

The Thermal Transient States

When the heat load or cooling load upon man reach magnitudes which exceed the capacity of the thermal regulatory system to achieve compensation, there will ensue rates of body thermal storage, positive or negative, which continue until the voluntary tolerance limit is reached. If there is no escape from these extreme conditions, or if one persists because of unusual motivation and in spite of intense thermal distress, the phenomena of hyper or hypothermic breakdown, collapse, and bodily injury occur. Beyond these generalizations the detail and pattern of events in heat and cold differ markedly.

Transient Response and Tolerance in the Hyperthermic Zone. The early experiments of McConnell, Houghten, and Yaglou of the ASHVE laboratory,[3] and the long series of UCLA observations[4] provide both a quantitative and qualitative picture of human response to high thermal-

[3] "Some Physiological Reactions to High Temperatures and Humidities," by W. J. McConnell, F. C. Houghten, and C. P. Yaglou, Trans. ASHVE, vol. 29, 1923, p. 129; vol. 30, 1924, p. 167.

[4] "The Prediction of Human Tolerance for Heat in Aircraft: A Design Guide," by W. V. Blockley, J. W. McCutchan, and C. L. Taylor, WADC Technical Report No. 53-346, Wright-Patterson Air Force Base, Dayton, Ohio, 1954.

Table 1 Composition of Physiological-Thermal Model Representing Conditions of Internal Heat Generation and Conduction, and Heat and Mass Exchanges With Environment

Component slab	Physiological characteristics	Thermal properties
Skin	Thickness and mass according to anatomical data	Fixed thermal capacity and conductance; no heat generation.
Functional peripheral shell	Subcutaneous tissue and a 0.4 in. of muscle, represented by mass and thickness; chosen from gradient studies which show greatest vasoconstriction-vasodilatation activity in this tissue.	Fixed thermal capacity; conductance varied with skin temperature; 1/4 metabolic heat generation in rest.
Functional central section	Additional mass of skeletal muscle, heart and blood; chosen to represent rapid heat conduction by blood transport and activity labile metabolic rate.	Fixed thermal capacity; conductance varied with deep body temperature; 1/4 metabolic heat generation in rest.
Core organs[a]	Composed of large organs: liver, kidneys, central nervous system. Being centrally placed and of high resting metabolic rate, they represent the internal origin of the heat-flow system.	Fixed thermal capacity; infinite conductance; 1/2 metabolic heat generation in rest.
"Inert tissues"[a]	Composed of skeleton and alimentary tract having relatively low metabolism and circulation.	Fixed thermal capacity; low and fixed conductance; no heat generation.

[a] Inert tissues and core organs are lumped together in the linear model described here.

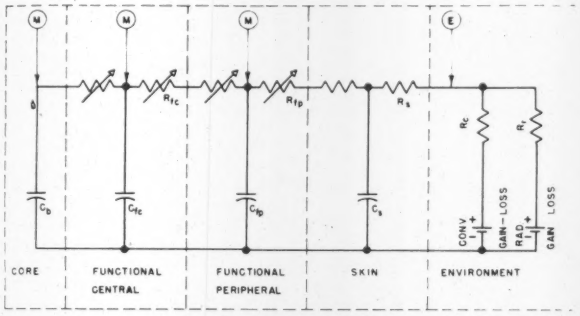


Fig. 4 Thermal circuit of human-environment system. M, E current sources representing metabolic inputs and evaporative loss. Notation: R, resistance; C, capacitance; $\frac{+}{-}$, potential source. Subscripts: b, core; 1, inert tissue; f_c, functional central; f_p, functional peripheral; s, skin; r, radiation; c, convection

heat loads and furnish a rationale for the practical management of this rare but important industrial and military hazard.

Hypothermic Zone—Clothing Requirements. Transient hypothermic responses have been studied in great detail but the results do not lend themselves to convenient generalization. For one thing, the differential cooling of extremities and trunk makes it difficult to express the effects in a common body parameter. For another, physical activity and clothing are the predominant factors, and usually these are so freely under the choice of the individual that painstaking display of innumerable body thermal states seems to have little point. On the other hand, the clothing required for thermal balance at various activity levels is a meaningful and practical question.

Biotechnical Methods for Human Thermal Problems

Conventional Methods. The design of human thermal environments is the task of the engineer. The biological information underlying design comes from many sources, such as, physiological experiment, climatological observations, and controlled studies of thermal comfort in various environments. Technical calculations are based upon data for heat transmission of materials, air leakage, radiant sources, and the like. From these the heating and cooling requirements are estimated to obtain a steady-state environment of temperature, humidity, and air movement. Indexes of thermal effect, such as the "Effective Temperature Scale"[1] or the "Index of Warmth"[5] which adds the effect of radiant surround, are useful guides for the design of optimal thermal conditions.

Development of a Biothermal Analog Computer. The value of the analog computer for obtaining rapid approximate solution of thermal problems in engineering components and systems is well known. The possibility of utilizing this method is being explored thoroughly at the University of California by Norman E. Friedmann.

As a first step, we must conceive a physiological-thermal model which properly represents both the conditions of internal heat generation and conduction, and the heat and mass exchanges with the environment. To this end a large amount of anatomical and physiological data have been collected and compared, both to give values that enter directly into the composition of the model and to provide functions and check points that outline the behavior of the model. The composition of a thermal model, which consists of a linear series of slabs of unit area, is shown in Table 1.

The thermal circuit for the system in electrical notation is shown in Fig. 4. The design of the computer follows the conventional thermal-electric analog, and contains cells of capacitors and resistors to permit many combinations of thermal properties. Boundary conditions are controlled by potential sources, current sources, and resistance units which simulate the body-environment heat exchanges. Current sources within the model provide simulation of metabolic heat production.

It cannot yet be reported how closely the computer will simulate human thermal responses. The ultimate check is against human experimental data, and agreement with actual skin and rectal-temperature curves is the crucial test. Presently, validation is being sought for nude, sitting man in extremely hot environments. It is planned, if this is successful, to add a clothing section, and to extend the simulation also to the conditions of physical exercise and to cold environments.

[5] "Environmental Warmth and Its Measurement," by T. Bedford, Medical Research Council, London War Memo. 17, 1946.

Briefing the Record

Abstracts and Comments Based on Current Periodicals and Events

J. J. Jaklitsch, Jr., *Associate Editor*

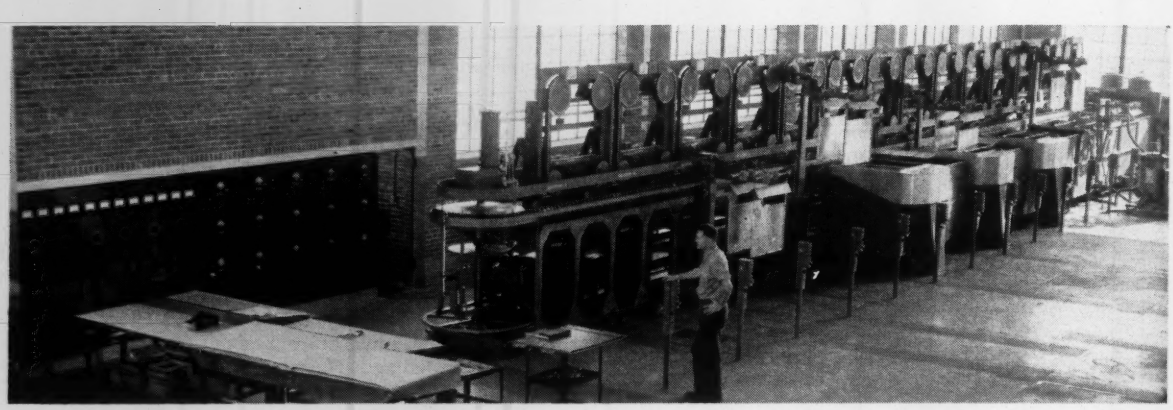


Fig. 1 Full view of automatic plating machine which has provision for 13 different stages of plating and/or cleaning. The tanks are 400-gal capacity and include rubber-lined, lead-lined, and unlined steel to cover a variety of plating needs. The machine is completely automatic except for loading and unloading and can be used in single or double-line operation.

Nickel Research

A NEW plating laboratory, the main feature of which is the world's only fully automatic pilot plating plant, was unveiled recently at the Bayonne N. J., Research Laboratory of The International Nickel Company, Inc. This pilot plant for the first time permits the testing of new plating processes and metallic coatings under conditions virtually similar to those existing in actual industrial plating plants.

At the same time the company announced the development of three new products—two welding electrodes and a special, corrosion-resistant high-nickel alloy. One of the new electrodes, Inco-Rod "A," a multipurpose rod, is expected to reduce substantially electrode inventories in the average plant. The other, "132" Inconel electrode, welds Inconel to itself. The third product, Nionel, is a versatile high-nickel alloy capable of resisting corrosive attack by a large number of hot acids and mixtures of acids.

Plating Laboratory

The laboratory's fully automatic plating line is capable of producing coated-metal test panels in large numbers with an extremely high degree of control to assure uniformity. Together with data obtained in their production, these panels provide the plater with an accurate forecast of the feasibility of a new plating method or new-type coating. The automatic equipment has provision for 13 different stations of plating and can be used in either single or double-line operation, handling work up to three feet in cross section. It can be operated entirely from a central panel board where time, current, and voltage for each stage of a cycle can be observed and controlled. Power for cleaning and plating, operations is supplied by a bank of six rectifiers, each rated at 1000 amp at 12 volts and 2000 amp at 6 volts.

The automatic transferring and conveying system permits work to remain stationary at any given position for as long as desired, varying from as little as five seconds to as much as several hours, or even days.

One particularly interesting project now in progress

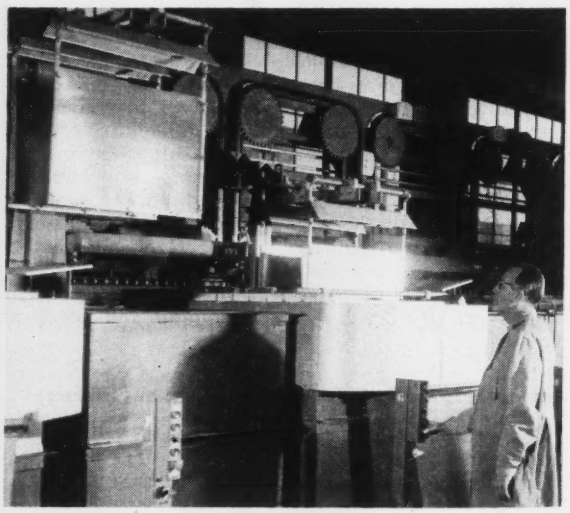


Fig. 2 Control operator is shown monitoring plating operation at rinse stage during automatic plating cycle

at the laboratory is the research being done in co-operation with container manufacturers and their suppliers of can stock. This involves extensive investigation into the merits of thin nickel plating for can coatings.

Inco-Rod "A"

The new multipurpose electrode, Inco-Rod "A," designed to fill a long existing need for an electrode

Fig. 3 Finished butt-welded joint of mild steel and stainless steel made with $^{5}/_{32}$-in. Inco-Rod "A" multiple-purpose rod. Note close ripples and smooth contour of weld bends.

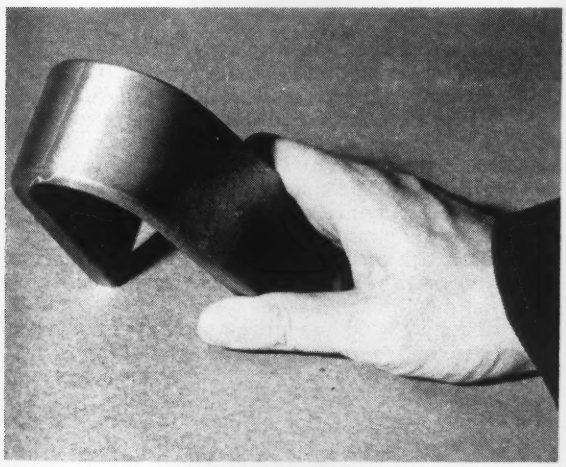


Fig. 4 Bend specimen cut from an Inco-Rod "A" butt-welded joint of mild steel and stainless steel showing high order of ductility and freedom from cracking in deposited metal

capable of making sound joints between a large number of metals and alloys of different compositions, is expected to supplant many of the electrodes now required in plant stocks. It is anticipated that this electrode will give high-quality welds on better than 90 per cent of the dissimilar welding jobs. The area of its greatest usefulness will be in the joining of ferritic (mild and low-alloy steels) materials to stainless steels. In addition, the new

Fig. 5 View of a boiling nitric-acid test shows no apparent attack on specimen of Nionel

electrode permits these groups of alloys to be successfully joined to high-nickel alloys, such as Monel and Inconel.

Inco-Rod "A" brings to fruition a long-standing theory—that high-nickel alloy-type compositions are particularly well-suited for dissimilar metal welding. In all tests made on the welding of dissimilar metal combinations with the new electrode, the welds were found to be sound and ductile, possessing excellent strength. In addition, the corrosion resistance of the weld deposits in most cases was superior to that of the metals involved.

"132" Inconel Electrode

This new development represents an improvement of one of the company's products, "132" Inconel electrode, which is used to weld the high-nickel alloy, Inconel, to itself. The principal advantage of the improved electrode is that radiographic quality welds are possible with the electrode in the "as-received" condition. Previously it was necessary for the user to re-bake the electrode in his plant to insure top-quality welds.

Nionel

Nionel is a high-nickel alloy containing approximately 40 per cent nickel, 21 per cent chromium, 3 per cent molybdenum, 1.75 per cent copper, 31 per cent iron, and

small amounts of manganese, silicon, and carbon. The relatively high nickel content, plus molybdenum and copper, makes this alloy considerably more resistant to hot sulphuric, sulphurous, and phosphoric acid solutions than any of the common stainless steels. In addition, the chromium content is sufficient so that when fortified with nickel, the alloy is capable of resisting a wide variety of oxidizing chemicals.

Nionel is expected to find major applications in the sulphuric-acid pickling of iron, steel, and copper-base alloys; in petroleum refineries, synthetic detergent plants, rayon manufacture, ore-processing plants, and the pulp and paper industries. It has shown good resistance to pitting attack in sea water and, therefore, should have many applications in tubular heat exchangers.

Crack-Free Chromium-Plating Process

A NEW production-plating process that deposits a chromium plate directly on steel and which provides much better resistance to corrosion than ordinary chromium plating was announced by United Chromium, Inc.

Known as "Crack-Free Chromium," the new plate is deposited free of any structural imperfection that would allow corrosive materials to come in contact with the underlying surface being protected. As a result, it can be plated directly on steel, without the necessity for an undercoat of nickel or copper and nickel.

Other desirable properties of the deposit produced by the new process include low coefficient of friction, excellent adhesion, a nongalling surface, and superior ductility as compared to ordinary chromium finishes. The crack-free deposit has an attractive light gray matte appearance. It can be readily buffed to a high luster.

A photomicrograph of a cross section of the Crack-Free plate shows a dense, continuous structure rather than cross sections of cracks which extend through the deposits in a similar photomicrograph of ordinary chromium plate. Ordinary chromium deposits more than 0.0001 in. thick show cracks which permit corrosive agents to reach the underlying metal. At the decorative thicknesses, the ordinary chromium deposit contains pores, varying in number with plating conditions. As the deposit thickness increases, the number of pores increases, but a cracked structure develops and continues regardless of the increase in thickness. Corrosive media can filter through these discontinuities in the plate to attack the base metal. To cope with this situation, chromium-plating practice heretofore has called for a deposit of nickel under the chromium. The Crack-Free Chromium process is said to solve the problem and permit direct chromium plating on steel with assurance that it will be effectively protected against corrosion.

Chromic-Acid-Type Bath

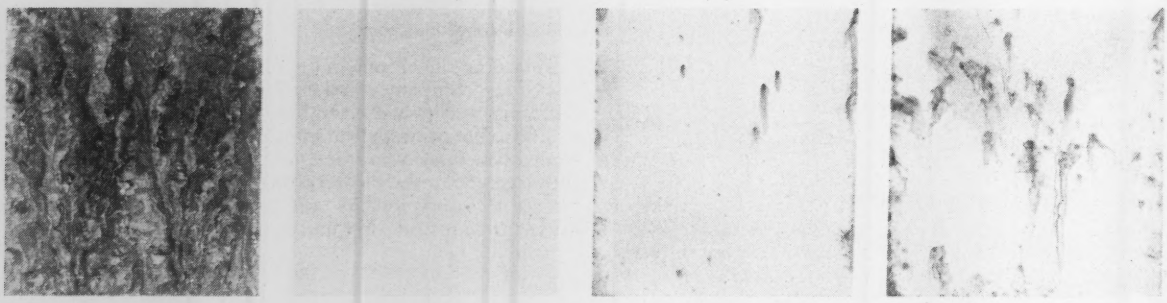
Unichrome Crack-Free Chromium plating is done with a special chromic-acid-type bath having automatic regulation of the catalyst concentration. Standard plating equipment and procedures are used. The bath is prepared by simply dissolving the proper amount of a single compound, Unichrome SRHS Compound CF-500, in water. The same compound is used for maintenance. According to field reports, the bath is easy to operate and maintain. The Crack-Free bath has good throwing power. Its plating speed is about the same as that of ordinary chromium.

A summary of the properties claimed for the Unichrome CF-500 Crack-Free deposit follows: (1) Much better corrosion resistance than ordinary chromium plated directly on steel; (2) remains crack-free when heated to 1000 F and plunged into water; (3) softer and more ductile than ordinary chromium (500 to 700 Knoop as compared to 800 to 1000 Knoop hardness); (4) excellent adhesion; (5) improved nongalling, nonseizing, and leveling properties; (6) Crack-Free Chromium plated directly on steel provides the same protection as the commonly used composite copper-nickel-chromium decorative finishes.

Successful Field Installations

To protect shafts from rusting and at the same time to get both chemical and wear resistance, The Maytag Company, Newton, Iowa, recently put into production an automatic plating machine to plate Unichrome Crack-Free Chromium directly on steel. After 100 hr of exposure to salt spray, a steel shaft plated with 0.0005-in. ordinary chromium was completely covered with rust; a shaft plated with an equal thickness of Crack-Free Chromium exposed to the same conditions was practically unaffected. The company also reported that the new-type deposit possesses excellent leveling characteristics. Washing-machine shafts which initially had 30 to 50-microinch finish had a finish of 3 to 7 microinches after plating with 0.3 to 0.4 mil of Crack-Free Chromium.

Even where high corrosion resistance was not of prime



Ordinary—24-hr exp. Crack-Free—24-hr exp. Crack-Free—100-hr exp. Crack-Free—175-hr exp.

Fig. 6 Salt-spray-test results of 0.003-in-thick chromium plated directly on steel without nickel or copper and nickel undercoat

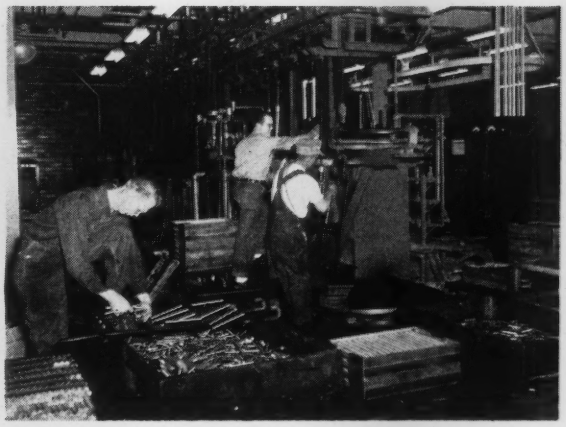


Fig. 7 Fifteen important parts—including shafts, pivots, tubing, stems, and retainers for Maytag's automatic washers and dryers—are Crack-Free Chromium plated for corrosion and wear protection. In *left* photo, men are loading racks with unplated parts. Light gray parts in foreground and left and extreme right have been plated. Plating equipment, *right* photo, consists of a chainless type-fully automatic plating conveyer and nine tanks. The latter include, in operation sequence, anodic clean, two rinse-and-spray, anodic etch, chromium plating, drain-fog spray, two rinse-and-spray, and soluble oil.

importance, Crack-Free Chromium has proved advantageous according to United Chromium's field engineers. One company that used the new plating process on their cold stamping dies for embossing silverware reported that the Crack-Free deposit gave 20 per cent longer life than ordinary chromium. Another manufacturer, who punches aluminum tumblers in a series of draws, eliminated production difficulties due to the tumblers sticking and seizing in the dies after the dies were plated with Crack-Free Chromium.

Decorative Finishes

In addition to industrial applications where corrosion and wear resistance, good adhesion, and ductility are required, the new Crack-Free Chromium plating process holds promise for decorative chromium finishing.

Where a nonreflective finish is required, Crack-Free Chromium would be a "natural" since the unbuffed deposit is a light gray matte. A manufacturer of desk, closet, and drawer hardware is utilizing this characteristic to obtain an attractive two-tone finish. Zinc diecastings are first plated directly with the Crack-Free Chromium to a thickness of approximately 0.3 mil. The two-tone effect is then obtained by highlighting the pieces with a buffing operation.

For most decorative applications it is necessary to buff if a high luster is to be obtained. However, the buffing operation is not prolonged or heavy but rather similar to buffing dull nickel plate. The savings resulting from the reduction or elimination of the undercoats, as well as the improved product appearance and service life, more than balance the cost of the extra buffing operation.

High-Temperature Lubricants

DEVELOPMENT of a new series of high-temperature lubricants—needed by tomorrow's faster jet planes—was announced during the 127th national meeting of the American Chemical Society in Cincinnati, Ohio.

The new fluorine—containing synthetic oils, which are not decomposed by temperatures as high as 500 F, should find application in aircraft gas-turbine engines and new high-temperature electric motors and generators, declared Harold Ravner, a physical chemist of the Naval Research Laboratory, Washington, D. C. He said that the lubricants may also be useful for submarines because they are heavier than sea water and therefore would not form an oil slick on the surface of the water to reveal the presence of a submerged submarine.

The synthetic lubricants equal petroleum oils in lubricating ability and are much more resistant to the deteriorating action of oxygen at high temperatures, Mr. Ravner reported. The new compounds are known as diesters of fluoroalcohols, he explained, and they withstand high temperatures because of the fluorine atoms attached to the ends of the molecular chains. He said they may also find use in hydraulic systems.

The fluorine-containing diesters are less susceptible to fire and explosion hazards than are petroleum oils.

"Many of the diesters of fluoroalcohols have spontaneous ignition temperatures ranging from 850 F to more than 1000 F. Mists of such compounds, with fluorine contents of more than 55 per cent, are not explosive in pure oxygen at 200 F," Mr. Ravner said.

"In general, esters of fluoroalcohols and dibasic acids are remarkably resistant to oxidation as compared with conventional oils. Laboratory tests reveal that certain such substances undergo no deleterious changes when aerated at 400 F. Other diesters containing less fluorine show degradative changes under such conditions. Diesters of fluoroalcohols are thermally stable at 500 F.

"Preliminary friction and wear tests indicate that fluoroalcohol diesters are comparable to petroleum oils in lubricating ability. Although the heaviness of these esters at low temperatures may limit their use in aircraft hydraulic systems, they may well find use on shipboard and in industrial installations where low-temperature requirements are not so stringent, but high-temperature stability is a requisite. Preliminary tests indicate that these synthetic oils cause little attack on rubber.

"Greases based on the fluorine-containing esters have been made. Experience to date indicates their usefulness in antifriction bearings operating at high temperatures."

C. M. Henderson and C. M. Murphy were coauthors of Mr. Ravner's paper.

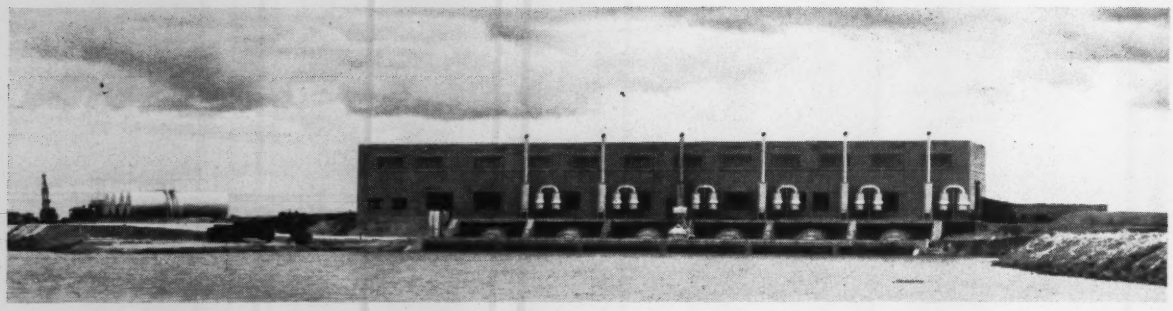


Fig. 8 World's largest low-lift pump plant, Station 5A, stands at 20 Mile Bend, midway between Lake Okeechobee and West Palm Beach in Florida. Its six Fairbanks-Morse pumps can move 2,160,000 gpm from the West Palm Beach Canal into the conservation area to the south. This view shows the suction side of the station.

Giant Pumping Station

THE world's largest self-powered pumping station went into service recently as the heart of a gigantic water-control system that promises to tame, for all time, the rampaging flood waters of the Florida Everglades, end the threat of crippling drought, and reclaim millions of acres of rich farm land.

Horizontal Axial-Flow Propeller Pumps

Located at 20 Mile Bend, midway between Lake Okeechobee and West Palm Beach, the new station houses six 116-in. Fairbanks-Morse horizontal axial-flow propeller pumps, each with a capacity of 360,000 gpm at 11.1-ft static head. The combined capacity of 2,160,000 gpm (3,110,400,000 gal per day) makes the station the world's largest low-lift pump plant. Only the higher lift stations at Grand Coulee Dam and Mill Creek, Cincinnati, can pump more water. Each of the Florida pumps is driven by a 1600-hp Fairbanks-Morse opposed-piston diesel.

The six pumps are housed in a 226 × 44-ft hurricane-proof reinforced-concrete structure. Each pump has a 106-in. cast-bronze, four-blade, airfoil propeller weighing 13,400 lb. Pump and frame, exclusive of suction and discharge lines, weigh about 178,000 lb.

Water flows to the station through a short cutoff from the West Palm Beach Canal, passing through trash racks with $^1/_2$-in. bars spaced 6 in. apart to the suction bay for each pump. These bays are actually one long forebay with concrete splitters, set 30 ft apart, preventing any turbulence from one bay from affecting the others. The bottom of each suction bay is at 5.5 ft below mean sea level. The pumps go into operation at 13.0 ft above msl with normal drawdown to 8.3 ft and a maximum drawdown to 6.3 ft. Maximum discharge pool level is calculated at 19.4 ft. The pumps are rated on the basis of a static head of 11.1 ft. Since the invert of each pump is at 13.0 ft msl, the six pumps were provided with automatic-closing, semibuoyant discharge gates to prevent backflow. Each gate has three horizontal shutters of cellular construction which open easily in sequence when a pump is started, minimizing back pressure. The pumps are primed by 10-in. motor-driven mercury vacuum pumps. Should the discharge gates become inoperative, the same vacuum pumps can be used in reverse to put the big pumps under 4-lb pressure.

Diesels were chosen to drive the big pumps primarily to insure continuity of operation during storm periods when the plant would be most urgently needed and when electric-power-transmission lines would be most vulnerable. Also, the power and efficiency characteristics of diesels suited them admirably to operate axial-flow pumps at variable speeds to meet changing load conditions. Still another factor was the operating economy of diesels in a plant where annual service, equivalent to 52 days of full-capacity pumping, is anticipated. With purchased power for electric motors, demand charges would represent a sizable expenditure. The biggest factor by far, however, was the need for a dependable, weatherproof power supply.

10-Cyl Opposed-Piston Diesels

The engines picked for the jobs are 10-cyl Fairbanks-Morse opposed-piston diesels of $8^1/_8$-in. bore and 10-in. stroke, rated at 1600 hp each at 720 rpm. Each engine drives its pump at a rated speed of 124 rpm through double-reduction chain drives with a ratio of 5.80 to 1.

Fuel oil for the main engines flows by gravity from four 25,000-gal above-ground storage tanks, through separate full-flow strainers, to individual $1^1/_2$-in. motor-driven transfer pumps, located in the basement beneath each engine. It is then pumped under pressure through individual meters to separate 300-gal day tanks, mounted 36 ft above the operating floor and equipped with automatic float controls. From each day tank the fuel flows

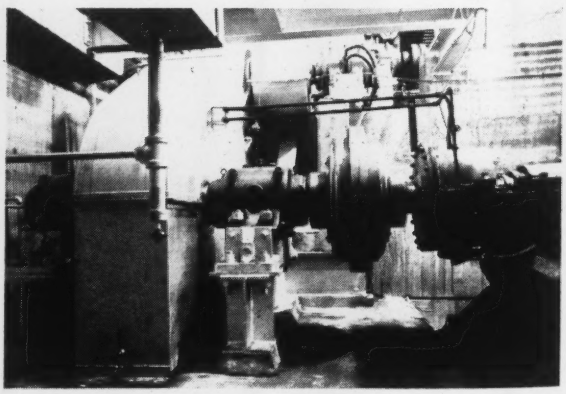


Fig. 9 This view taken from the pump chamber shows the Morse chain drive with flexible couplings and thrust bearings

by gravity to an engine-driven supply pump, thence under pressure through a newly developed duplex filter to the twin injection pumps and nozzles at each cylinder.

Lube oil is circulated under pressure through each engine by a built-in, engine-driven circulating pump, passing from the engine through a thermostatically controlled blending valve, through a shell-and-tube cooler, through a full-flow strainer, and back to the engine. A by-pass line at the pressure site of each circulating pump carries a continuous supply of lube oil to a cartridge-type cellulose-packed purifier. From this purifier the lubricating oil is then returned to the engine by a builtin $^1/_3$-hp motor-driven circulating pump.

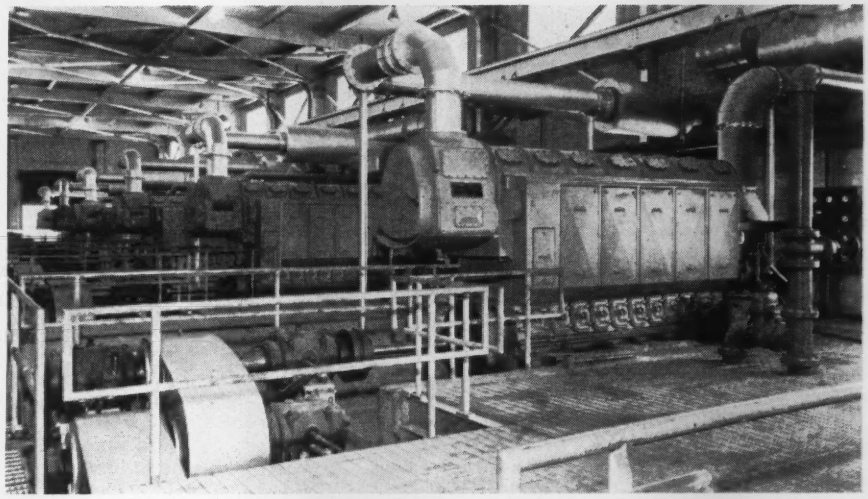


Fig. 11 Six 1600-hp Fairbanks-Morse opposed-piston diesels drive the huge pumps through double-reduction chain drives. Station 5A is the largest self-powered pumping plant in the world.

Both jacket-water make-up and raw water are taken from the West Palm Beach Canal, the jacket water being run through a water softener and chemical-treatment unit before addition to each closed system's expansion tank. A 6-in., 10-hp motor-driven centrifugal pump circulates the jacket water through each engine, through a thermostatically controlled blending valve, and through a shell-and-tube-type heat exchanger.

Raw water is circulated through each lube-oil cooler and heat exchanger by another 6-in., 10-hp centrifugal pump, reaching the 8-in., water-cooled bearings on each chain drive by means of a by-pass line from the pressure side of the pump.

Scavenging air for the six main engines is drawn through individual oil-bath-type filters, arranged along the outside wall, just above the suction bays. Bracketed to the same wall, but high enough to avoid interference with the filters, are six vertical exhaust silencers.

Electric power for lighting and for all motor-driven auxiliaries is supplied by three 5-cyl, 750-rpm, Model 31A6$^1/_4$S, Fairbanks-Morse diesel engines, driving three 100-kw, 125-kva, 3-phase, 60-cycle, 480-volt alternators, direct-connected to individual 3-kw, 125-volt, d-c exciters. With this external power plant, the station is freed from dependence on outside electric-transmission lines and is assured of continued operation throughout storm and hurricane periods.

To further insure that this plant can get into operation quickly, the engineers have provided a 28-hp 1400-rpm, 3-cyl, Model 48AS4, Fairbanks-Morse diesel to drive a stand-by starting air compressor and a vacuum priming pump arranged in tandem.

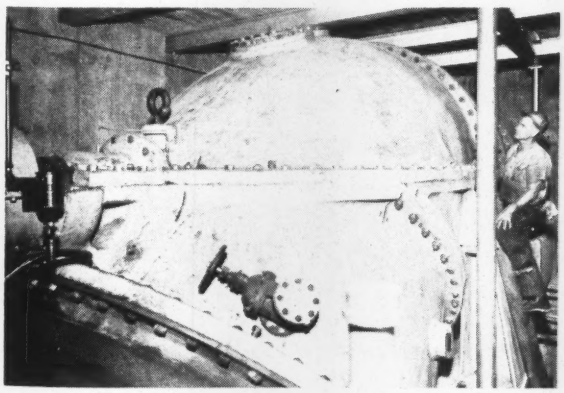


Fig. 10 The six 116-in. pumps are horizontal axial-flow propeller pumps rated at 360,000 gpm each

Testing Plastic-Bonded Materials

PLASTIC-ADHESIVE-BONDED structural sandwich material may consist of a honeycomb of light metal or textile-plastic laminate bonded by a plastic adhesive between layers of metal sheet. This construction combines high strength with light weight, which are the qualities needed for structural members of air frames, as for wing and tail sections. Plastic adhesive-bonding is also used in helicopter blades and in propellers filled with foamed plastic.

In all plastic-bonded parts, a complete bond is essential. A poor bond in a sandwich wing or a propeller filled with foamed plastic could be disastrous.

The necessity of a sure bond poses a problem that seriously limits the use of sandwich and similar materials in aircraft construction. How can the quality of the bond be determined without destroying it? If a designer cannot reply on a sure bond, he must be overgenerous and thereby forfeits much of the strength-weight advantage of the material.

A nondestructive test device, called a Stub Meter, has been developed by physicists of Stanford Research Institute, Stanford, Calif. To check the completeness of the bond a vibrating piezoelectric ceramic probe connected to the meter is held against the sandwich sur-

face. The reaction of the probe vibration to the metal structure immediately below the area of contact results in an electrical response that indicates the presence or lack of a good bond between metal and adhesive. This response is registered as a wave pattern on an oscilloscope screen. If it deviates from the pattern for a panel known to be sound, a faulty bond is indicated. To an experienced operator the wave shape suggests the nature of the defect. Also, from the measurements on the pattern, the physical strength of the bond can be predicted with satisfactory certainty.

The Stub Meter is expected to have application not only for nondestructive testing of plastic-bonded, metal-sandwich materials but also plastic laminates, possibly wood laminates, and clad metals. The meter is not restricted to laboratory use but can be built in a form for quality-control applications either in factories or for field inspection.

Rubber Journal-Box Lubricator

A SPONGE-RUBBER lubricator, designed to eliminate freight-car journal hotboxes, has been developed by United States Rubber Company.

Called Ever-Pac, the device forms a sealed oil reservoir at the bottom of the journal box, and pumps, squeezes, and wick-feeds filtered oil into a felt pad that is in constant contact with the rotating journal. It is said to give smooth, controlled, and fully adequate journal lubrication.

Easily slipped into the journal box in a matter of minutes, it prevents the loss of oil by leakage or splashing, without the use of costly oil seals or special types of dust guards. No welding, drilling, or machining of the journal box is necessary.

Waste-grab, the major cause of hotboxes, is eliminated because the waste packing itself is eliminated, and with it the expensive and laborious process of waste renovation and replacement. Oil consumption is cut by more than half and original installation and replacement costs are reduced sharply.

The lubricator, U. S. Rubber estimates, can save the railroads over $200 million annually. This is based on the toll of the hotbox in reported accidents, derailments, wheel changes, and the like, and present high cost of renovating and using waste packing.

Oil feed to the journal by the U. S. Rubber lubricator remains adequate and constant, regardless of oil level in the reservoir, and continues for a long period even after all the oil in the reservoir has been used. This is because of the extra supply of oil absorbed and retained by the sponge rubber and wick-pad when the lubricator is saturated before installation.

In comparative laboratory tests journal-bearing temperatures rose 41 deg between speeds of 60 to 10 mph when cotton waste was used, but only 12 deg with use of the new lubricator. At 80 and 100 mph, waste packing produced maximum bearing temperatures that were from 9 to 22 deg higher than maximum bearing temperatures developed at the same speeds with the Ever-Pac publicator. Tests at subzero temperatures showed no displacement of the lubricator and no tendency for it to "freeze down" and lose contact with the journal.

The device has been approved by the Association of American Railroads for limited installation on cars used in general interchange service—that is, cars that operate beyond the owner's tracks. It may be installed without limit on so-called "captive" cars, which are cars kept in service only on the owner's line.

The lubricator consists of an absorbent synthetic sponge-rubber pad which is resistant to oil, acids, heat, and abrasion, with a highly-absorbent felt wick-pad fitted to the top surface of the sponge rubber like a

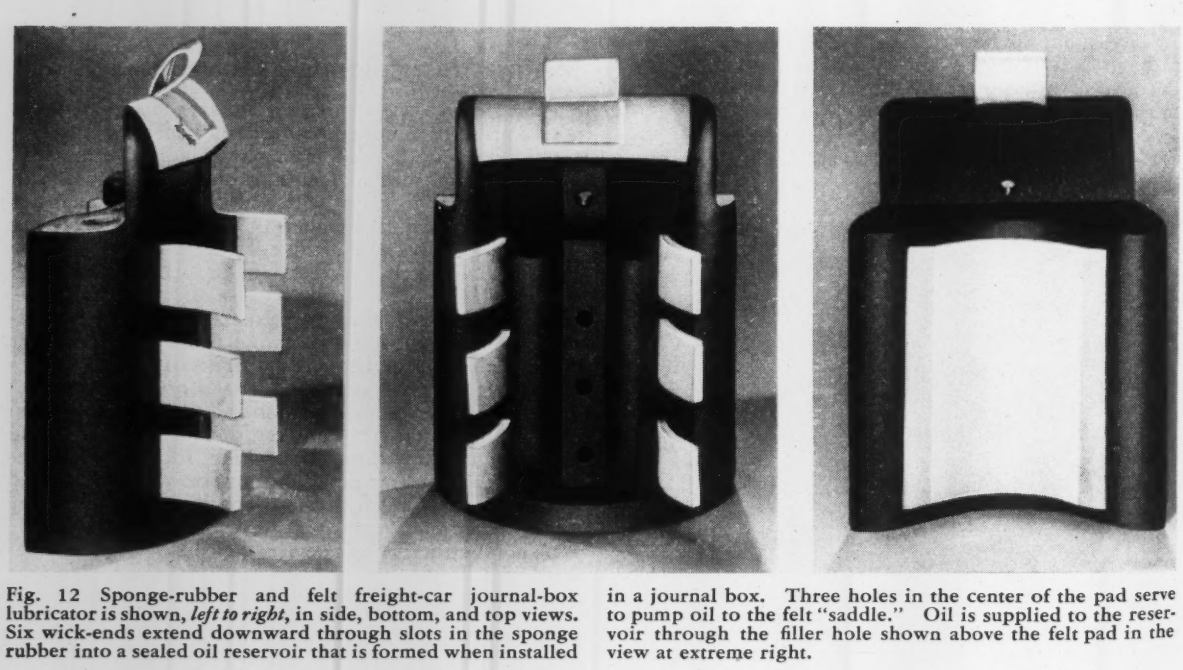


Fig. 12 Sponge-rubber and felt freight-car journal-box lubricator is shown, *left to right*, in side, bottom, and top views. Six wick-ends extend downward through slots in the sponge rubber into a sealed oil reservoir that is formed when installed in a journal box. Three holes in the center of the pad serve to pump oil to the felt "saddle." Oil is supplied to the reservoir through the filler hole shown above the felt pad in the view at extreme right.

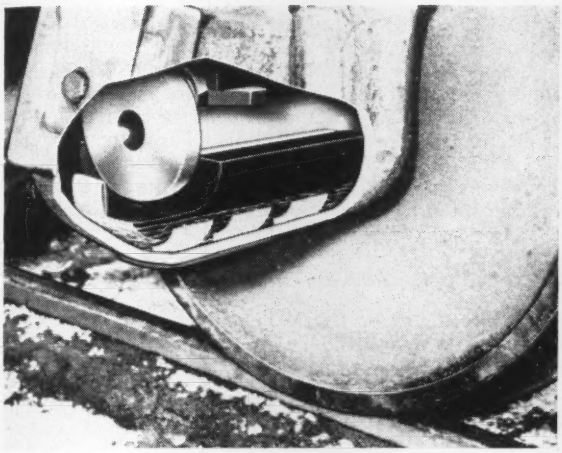


Fig. 13 Cutaway view of freight-car journal box shows new journal lubricator in position. The device eliminates waste packing and provides a constant three-way oil delivery to the journal by capillary action, pumping action, and sponge-pad flexing.

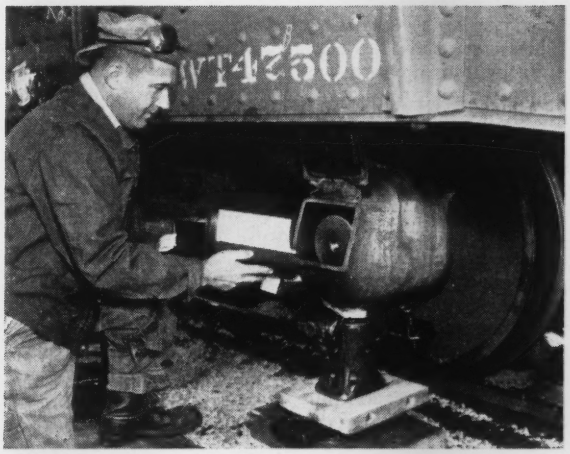


Fig. 14 New sponge-rubber and felt journal lubricator is ready to be slipped into position underneath freight-car journal. It takes less than two minutes to install after journal box has been jacked and bearing and wedge have been removed.

saddle. This wick-pad is in constant contact with the underside of the journal.

Six wick-ends pass through slots in the sponge-rubber pad down into a rectangular-shaped recess formed by the underside of the sponge pad. The recess provides an entirely enclosed oil reservoir at the bottom of the journal box, holding two pints of oil.

Another two pints are absorbed by the sponge-rubber pad and wick during saturation before application, making a total of two parts of oil available for lubrication. The wick is readily changeable.

The device provides a three-way oil delivery to the journal by capillary action, pumping, and flexing of the sponge pad. The oil is pumped by journal or journal-box movement, through three vertical holes in the pad directly underneath the wick.

Each vertical movement of the journal or journal box, caused by jolts, low-rail joints, severe brake applications, and pressure against the sponge-rubber pad by thrust motion of the journal, compresses the pad and forces oil upward through the holes thereby saturating the distributing wick.

In addition to pumping action of the sponge-rubber pad and capillary action by the wick-ends in the reservoir, oil is also squeezed from the saturated sponge and transferred to the wick when the pad is flexed only by the rotation of the journal or slight movement of the journal box.

Oil is supplied to the reservoir through an oil-filler hole at the front end of the lubricator below the journal-collar area. If slight pressure with a finger or packing tool brings oil to the top of the hole, the reservoir contains enough oil.

The lubricator provides a constant, cushioned upward pressure against the journal surface, producing an even and controlled rate of oil distribution. Special tools and guesswork as to how much oil should be added are eliminated.

By reason of its compression fit, the lubricator molds itself against the sides and ends of the interior of the journal box and cannot be dislodged. This prevents loss of oil through front and rear openings of the journal box and entry of water or dirt, thus insuring clean oil for lubrication. Both the wick and sponge rubber filter out foreign matter from the oil before it reaches the journal.

Although it is necessary to jack the journal box and remove the journal bearing and wedge to apply the device, removal and inspection of the bearing and wedge are also necessary with each change of waste packing. Actual insertion of the lubricator requires less than two minutes. A set of eight lubricators, enough for one freight car, costs $60.

Engineering-College Enrollment

ENGINEERING-COLLEGE enrollment has increased for the third consecutive year—after successive annual declines from a post-World War II high of 244,390 in the fall of 1947 to a post-World War II low of 147,894 in the fall of 1951, according to a report in the *Journal of Engineering Education*, February, 1955, by William A. Jaracz and Henry H. Armsby.

Mr. Jaracz is head, Statistical Services Unit, Research and Statistical Standards Section, U. S. Office of Education, Department of Health, Education, and Welfare. Mr. Armsby is chief for Engineering Education.

There were 187,454 engineering students enrolled (at all levels) in schools accredited by the Engineers' Council for Professional Development in the fall of 1954, an increase of 9.1 per cent over the number enrolled in such schools in the fall of 1953. Although this constitutes a considerable increase, it is a somewhat smaller increase than was experienced by all institutions of higher education, in which total enrollment increased 11.1 per cent, and male enrollment increased 11.8 per cent.

Enrollment of Freshmen

Freshmen-enrollment gains made by engineering schools (5.8 per cent) are considerably smaller than those experienced by higher educational institutions generally

(12.4 per cent). This difference becomes more pronounced when the 5.8 per cent increase in new engineering students is compared with a 14.9 per cent increase in the first-time male enrollment in higher educational institutions, generally.

Unlike total engineering enrollment, which has increased annually at an increasing rate since the fall of 1951, freshmen engineering enrollment has increased at a declining rate: The figure for the fall of 1952 was 34.3 per cent greater than for 1951, that for 1953 was 14.5 per cent greater than that for 1952.

A comparison for first-time enrollment for the nation as a whole with freshman enrollment in schools accredited by ECPD brings to light certain dissimilarities. The post-World War II low for first-time enrollment in all institutions occurred in the fall of 1951, whereas the corresponding low for the number of engineering freshmen came one year earlier, in 1950. As a result of this, a decline in first-time enrollment in all colleges in the fall of 1951 was accompanied by an increase of 16.2 per cent in the enrollment of engineering freshmen. In 1952 and 1953 there were increases both in total first-time enrollment and in freshmen engineering enrollment, with the latter registering the greater gain. The increase in the enrollment of engineering freshmen in the fall of 1954, however, was, as indicated, considerably smaller than the increase in first-time students, generally, indicating a rather marked reversal in trend.

This conclusion is further borne out by the changes in the ratio of freshmen engineering enrollment to total enrollment of first-time students for the past few years. This ratio increased from 5.7 per cent in 1950 to 7.2 per cent in 1951, to 8.5 per cent in 1952, and to 9.2 per cent in 1953—but declined to 8.6 per cent in the fall of 1954. The declining proportion of freshmen engineering enrollment vis-a-vis the total first-time enrollment is surprising in view of the widespread publicity with respect to the shortage of, and great demand for, engineers.

Undergraduate Enrollment

Undergraduate engineering enrollment, as is true of engineering enrollment generally, has increased for the third consecutive year. The 167,103 undergraduate engineers enrolled in the fall of 1954 represent an increase of 11.1 per cent over the undergraduate engineering enrollment in the fall of 1953. Since the increase from 1951 to 1952 was 7.6 per cent, and from 1952 to 1953 was 8.9 per cent, it is apparent that such enrollment has been increasing at an increasing rate.

Percentagewise, the undergraduate engineering enrollment is distributed by class level as follows: 32.2 per cent, freshmen; 22.9 per cent, sophomores; 17.2 per cent, juniors; and 13.6 per cent, seniors. Approximately 1.4 per cent are fifth-year students pursuing 5-year programs, and the remaining 11.7 per cent are part-time and evening students. These ratios are essentially those which obtained in the fall of 1953. There was an increase in enrollment at all levels with the exception of fifth-year students. Part-time and evening-student enrollment of 19,527 in the fall of 1954 constitutes an increase of 15.6 per cent over the fall of 1953 and is an all-time high. This increase is much greater than the increase in total undergraduate engineering enrollment, reflecting the increased interest in such programs.

About 56 per cent of all undergraduate engineering students were enrolled in three of the engineering curricula, namely, electrical (22.1 per cent); mechanical (21.0 per cent); and civil (12.9 per cent). The corresponding figures for the fall of 1953 were 55.3 per cent for the three curricula, and 20.6 per cent for electrical, 20.9 for mechanical, and 13.9 for civil. The increase of 1.5 percentage points in electrical engineering places it slightly ahead of mechanical engineering in the 1954 ranking, the reverse situation having obtained in the fall of 1953.

Unclassified Undergraduate Enrollment

Last fall, 94 schools reported a total of 27,232 unclassified students, or 16.3 per cent of the total undergraduate enrollment. The greater part of such students are found in the freshmen class and among evening students. Approximately 30.3 per cent of the freshmen class, and 44.6 per cent of all undergraduate evening students were unclassified with respect to the particular engineering discipline which they planned to pursue. In the fall of 1953, on the other hand, 86 schools reported a total of 22,608 unclassified students, or 15.0 per cent of the total undergraduate enrollment. Approximately 28.4 per cent of the freshmen class, and 37.0 per cent of undergraduate evening students were unclassified.

First Degrees

The number of male students upon whom undergraduate engineering degrees were conferred in 1953–54 was 9.1 per cent smaller than the number of conferrals in the previous year. This is a larger decline than that of 6.6 per cent in the number of first degrees conferred on male students in all institutions of higher education. Of all first degrees granted to men students by all degree-granting institutions in 1953–54, 10.5 per cent were in engineering. This constitutes a decline from the ratio of 10.8 per cent which obtained in 1952–53, which, in turn, was smaller than the 11.9 per cent figure which obtained in 1951–52.

The conferral of first engineering degrees has declined annually since the peak year of 1949–50, when 48,160 were conferred, and reflects the decline in freshman enrollment after the fall of 1946. The 19,707 first engineering degrees conferred in 1953–54 were the smallest number of conferrals since 1946–47, and can be attributed to the fact that the entering freshman class of 1950 was the smallest in the post-World War II period. Beginning with 1954–55, it is expected that the number of first degrees conferred in engineering will increase annually for the foreseeable future, i.e., will reflect the annual increases in freshman enrollment subsequent to the fall of 1950. Rough estimates for the numbers to be conferred in the next three years are as follows: 23,000 in 1954–55, 30,000 in 1955–56, and 35,000 in 1956–57.

Almost two thirds (63.5 per cent) of all first engineering degrees were conferred in three fields: 24.5 per cent in mechanical engineering; 20.7 per cent in electrical engineering; and 18.3 per cent in civil engineering. The corresponding percentages for 1952–53 approximated these to within one half of one percentage point in each instance.

Graduate Enrollment

Until the fall of 1954, every post-World War II year has been witness to an increase in graduate engineering

enrollment. In the fall of 1954, however, there was a net decline of 1055 graduate students—consisting of an increase of 278 students enrolled in work leading to a doctoral degree and a decline of 1333 students enrolled for work leading to a master's or other predoctoral degree.

The net decline in the number of students enrolled in work leading to a master's or other predoctoral degree is, in turn, made up of an increase of 212 day students and a decline of 1545 evening and special students. Approximately 51.4 per cent of all students working toward a master's or other predoctoral degree were evening students in the fall of 1954, as compared with 56.1 per cent in the fall of 1953 and 57.4 per cent in the fall of 1952. A considerably smaller proportion (24.3 per cent) of the students working for doctorates in engineering, on the other hand, are evening students. The ratio was 23.4 per cent in the fall of 1953 and 22.8 per cent in the fall of 1952.

There also seems to have been a slightly decreasing emphasis on evening enrollment in so far as master's and other predoctoral enrollment is concerned, and a slightly increasing emphasis with respect to doctoral enrollment.

The decline in the number of graduate students is surprising in view of the existing demand for engineers with advanced educational attainment. The large proportion of graduate engineering students who are evening students does, however, indicate an awareness on the part of practicing engineers of the necessity of, and the benefits to be derived from, bettering their understanding of the complex engineering processes which are constantly being developed.

In view of the fact that graduate engineering enrollment declined from the fall of 1953 to the fall of 1954, while undergraduate engineering enrollment increased, graduate engineering enrollment constituted a smaller proportion of total engineering enrollment in the fall of 1954 than in the previous fall. These ratios for the past four years from 1951 to 1954, respectively, are: 13.1 per cent, 12.8 per cent, 12.5 per cent, and 10.9 per cent—indicating what appears to be a trend in the direction of a decline in the relative attractiveness of graduate engineering enrollment. The ratio of resident graduate enrollment to total resident enrollment for the college population as a whole was 10.1 per cent in the fall of 1953 (the latest date for which such data are available).

Although the largest number of undergraduate students are found in electrical, mechanical, and civil engineering, the 1954 data show chemical engineering replacing civil engineering as one of the big three in so far as graduate engineering enrollment is concerned. The enrollment in civil engineering at the master's level is larger than that in chemical engineering; however, the enrollment in chemical engineering at the doctoral level far exceeds the enrollment in civil engineering.

Approximately three fifths (59.6 per cent) of all graduate engineering students are enrolled in electrical, mechanical, and chemical engineering. Graduate students in electrical engineering accounted for 31.0 per cent of the total graduate engineering enrollment, the corresponding proportions for mechanical and chemical engineering being 17 per cent and 11.5 per cent, respectively.

The change in these ratios since the fall of 1953 was less than 0.5 percentage point in each instance.

Graduate Degrees

There was an 11.4 per cent increase in the number of engineering master's degrees conferred in 1953–54 as compared with 1952–53. This increase stands in marked contrast with the decline of 6.9 per cent in the number of master's degrees conferred by all institutions of higher education, and is a considerable change from the situation prevailing in 1951–52 and 1952–53, in each of which years fewer master's degrees in engineering were conferred than in the preceding year.

There were 590 doctorates conferred in engineering in 1953–54 as compared with 592 in 1952–53—a decline of 2. There was, however, an increase of 8.3 per cent in the number of doctorates conferred by all degree-granting institutions.

Mounting Tool Diamonds

A NOVEL method of mounting stones in diamond tools with crystal savings of up to 90 per cent has been developed by Dr. H. Tracy Hall, one of the General Electric Company Research Laboratory team members responsible recently for the creation of man-made diamonds.

In a conventional mount, as much as 90 per cent of the diamond used may be buried in the tool in order to gain rigidity and prevent loss of the stone. Dr. Hall mounts, for example, a considerably smaller diamond in a shallow cavity on the surface of a single-point wheel-dressing tool. Formerly, a deep cavity would have been necessary.

One secret is the use of titanium hydride as a "wetting agent," and a solder, such as silver-copper. The parts are brazed by induction or radiation heating in a high-vacuum system, or in an atmosphere of very pure argon or hydrogen gas. In strength tests, a small diamond tip mounted on a microtone blade and revolved at 56,000 rpm, placed a force of about 50,000 psi on the bonding area. However, this force was insufficient to dislodge the diamond.

The advantages claimed for Dr. Hall's process are fourfold: (1) The diamond is securely anchored to its mount. (2) The wasted "root," which in many cases is three fourths of the volume of the entire tool point, can be eliminated. (3) Much smaller diamonds can be

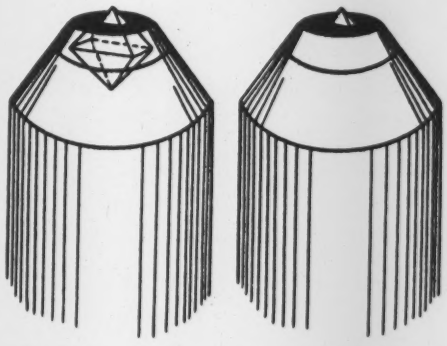


Fig. 15 Conventional method of mounting a diamond (*left*) compared with flush mounting with titanium hydride (*right*). Note diamond saving. Using the new technique, rough stones may be mounted with up to 90 per cent, or so, of the stone protruding, whereas up to 90 per cent must be buried in a conventional mount.

mounted to provide the same working surface. (Since diamond prices rise steeply with increasing size, a substantial saving results.) (4) Heat transfer is better when a diamond is bonded to metal than when there is only a mechanical connection. (A cooler working diamond will wear longer and is less likely to fracture from temperature shock.)

Hydrospin Machine

A MACHINE tool that squeezes cold alloy steels into desired shapes and that can cut in half production costs on many difficult-to-farm aircraft components has been installed in Solar Aircraft Company's San Diego, Calif., plant.

Known as a Hydrospin machine, the $100,000 36-ton unit was built by Cincinnati Milling Machine Company of Cincinnati, Ohio.

In the Hydrospin machine, a blank metal disk is rotated at high speed. As it spins two heavy-duty steel rollers force the metal disk into the desired shape, while the rollers advance along a preset course. The machine is semiautomatic—once the adjustments are set by an operator, various steps in the work cycle proceed automatically, except for loading and unloading. The machine is almost completely hydraulically controlled.

Solar will use the Hydrospin machine to manufacture jet-engine and other high-temperature parts, such as jet-exhaust cones. Numerous forming, welding, and machining operations on the cones can be eliminated through use of the Hydrospin. For example, one part is now made from a hemispherical casting, with additional machining and welding, for a total cost of $40. On the Hydrospin the entire cost would be $15. Substantial savings result from both lower material and labor costs, Solar production engineers said.

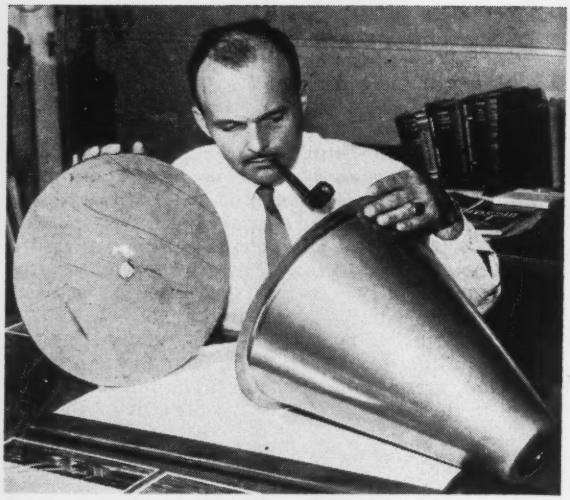


Fig. 17 J. A. Logan, chief production engineer of Solar Aircraft Company's San Diego plant, examines a spun-metal cone produced from a simple disk of metal like the one he is holding. The cone was fabricated on the Hydrospin machine.

In operation the Hydrospin employs two opposed rollers which force the material being worked to cold-flow onto a rotating mandrel. Pressure comes from four 50-ton hydraulic cylinders operating at 2500 psi. Stock up to 42 in. in diam can be handled, and the machine has successfully formed inch-thick mild steels and $^3/_4$-in-thick stainless steel. At Solar a five-ton bridge crane services the machine.

A major use for the Hydrospin is the production of dome-shaped contoured parts. In the past they have been fabricated in two sections and welded together, requiring both special dies and fixtures. On the Hydrospin they are simply formed from a black disk. On many parts, only one fourth as much material is said to be required to Hydrospin the part as to produce it from a forging, and production time is much less.

Another advantage of hydrospinning is that parts turned out are stronger, with greater resistance to fatigue, than components made by conventional methods. When metal is hydrospun, it undergoes a shear deformation, greatly

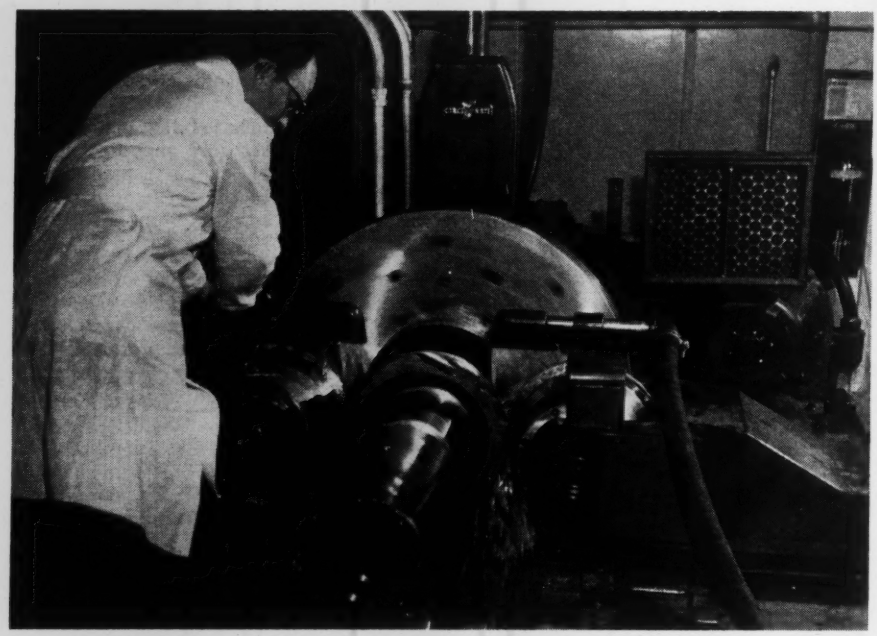


Fig. 16 Hydrospin machine squeezes cold alloy steels into desired shapes and sharply reduces production costs. The $100,000 machine rotates blank metal disks at high speed. As it spins the two steel rollers, shown in the photo at the sides, force the disk into a conical or contoured shape. Most of the machine's actions are automatic and follow preset courses determined by the operator.

elongating the metal's grain structure. The deformation results in work-hardening of the metal, and an increase in tensile strength, giving the part high-fatigue resistance.

Tape-Controlled Boring Machine

THE punched-tape principle of automatic operation has been applied to a precision-boring machine used in the production of instrument gear trains by Minneapolis-Honeywell Regulator Company. The system includes a standard four-spindle Excello precision-boring machine modified with built-in electronic controls and circuitry and a tape "reader" housed in a specially built control cabinet. This represents the first application of tape-controlled principles to a precision boring machine, it was claimed.

Hold co-ordinates and feed instructions are punched on the tape by a perforating machine similar to a typewriter. Electronic signals from the tape regulate the linear travel of the boring machine's hydraulic cross slide and the rotary motion of a specially designed holding fixture mounted on the cross slide.

Indications are that it is ideally suited for medium-sized production lots. Tooling and setup costs are said to be substantially lower than for punch-press piercing dies or drill ream jigs and operating costs are less than for jig borers.

Tape preparation requires approximately five minutes per hold and complete change-over from one part to another can be accomplished in about 30 min.

To set up automatic operation, the proper adapter ring is attached to the rotary fixture, cutting tools are mounted in the four spindles, and the punched tape is placed in the reader of the control circuit. After inserting a blank piece in the fixture, the operator merely presses a button to initiate the automatic tape-controlled cycle. After the machine has "read" the complete strip of tape, it automatically stops to permit removal of the finished part.

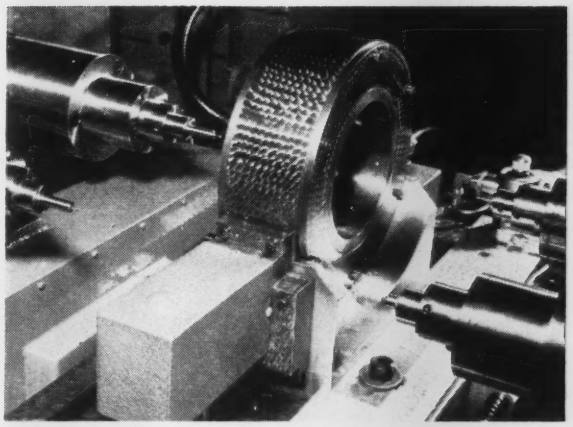


Fig. 19 The loop plastic tape sends out electrical impulses to regulate the linear travel of the machine's hydraulic cross slide (*lower left*) and the rotary motion of the holding fixture (*center*) mounted on the cross slide. To set up automatic operation, the proper adapter ring is attached to the rotary fixture; cutting tools are mounted in the four spindles; the tape is placed in the reader. After the complete tape has been read the machine automatically stops to permit removal of the finished part.

Fig. 18 Over-all view of tape-controlled automatic boring machine, developed by Minneapolis-Honeywell Regulator Company. It consists of a standard four-spindle Excello precision-boring machine (*upper right*) modified with built-in electrical controls, circuitry, tape reader, and manual controls housed in a specially built control cabinet (*left*). In the foreground an operator uses a perforating machine, similar to a typewriter, to punch hole co-ordinates and feed instructions on the tape. When placed in the reader of the control unit, the tape regulates linear travel of the machine's hydraulic cross slide and the rotary motion of the holding fixture mounted on the cross slide.

Designed for boring shaft holes in gear plates in which the center-to-center hold tolerances must be tight to prevent binding or backlash, the machine is adaptable to a variety of bold patterns and sizes, it is said.

Different piece parts can be handled merely by changing the adapter ring and inserting the appropriate tape. Where a small number of special plates is needed, the machine can be operated manually by adjusting 10 knobs to control linear travel of the cross slide and rotary motion of the holding fixture. Manual control knobs are located in control cabinet.

In either manual or tape-controlled operation, co-ordinate information is fed to the machine in increments of 0.0001 in. over the 8-in. linear range and 0.01 deg over the 360-deg rotary range. Accuracy is better than $\pm$ 0.0005 in.

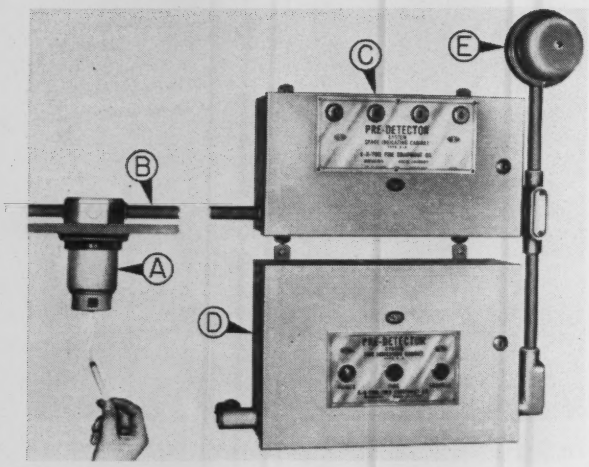


Fig. 20 Schematic arrangement of Pre-Detector System, here being activated by cigarette smoke, has three principal units: Pre-Detector head (A), space-indicating cabinet (C), and fire-indicating cabinet (D). Electrical conduit (B) and alarm bell (E) virtually complete assembly. Space-indicating cabinet, which may be used when two or more pre-detector heads are installed, shows location of fire in building, while fire indicator gives visual fire alarms, power failure, or system disturbance.

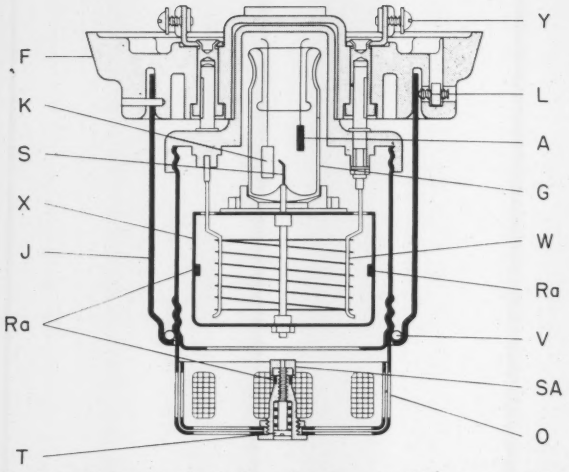


Fig. 21 Cross-sectional view showing working parts of the detecting device of the Pre-Detector System: O, chamber exposed to atmosphere; X, chamber virtually sealed from atmosphere; Ra, radioactive material; SA, sensitivity adjustment cap; T, sensitivity adjustment screw; G, gas-discharge (cold cathode) tube; A, anode; K, cathode; S, starter electrode; W, inner wire-grid electrode; J, locking shell; V, O-ring; F, socket base; L, locking set screw; Y, terminal screws.

Fire-Detection System

A MEANS of detecting fire in the earliest stage, without dependence on visible smoke or heat for actuation, was demonstrated recently by Pyrene—C-O-Two, of Newark, N. J. The radioactive, automatic C-O-Two Pre-Detector System gave visual and audible alarms within seconds after the ignition of various type fires.

With pre-detector heads, containing the radioactive element, spaced on centers up to 60 ft apart or up to 30 ft from side walls, the system can quickly detect the smallest smoldering fire and indicate the location where it occurs. It can also alert the public fire department and perform any number of functions to keep fire damage at a minimum.

Pilot installations have been made, it was stated, in a television station, a railroad signal tower, an electric-power plant, network analyzer room, two air-line flight-training equipment rooms, and the offices of an insurance company. Other uses indicated were the safeguarding from fire of merchandise warehouses, fur-storage vaults, all kinds of electrical equipment, air-conditioning equipment, aircraft hangars, racing stables, art galleries, museums, libraries, and private residences.

How the System Works

Heart of the Pre-Detector System is an overhead detection device electrically connected to a fire-indicating cabinet. The concept of this pre-detector head is based on earlier European research on the ionization chamber principle of fire detection. Each head contains a highly sensitive gas-discharge (cold cathode) tube, plus two independent chambers, one of which is exposed to the atmosphere and the other virtually sealed from the atmosphere. A minute source of radioactive material is mounted in each of these chambers, and the radiation ionizes the air in the respective chambers, causing it to become electrically conductive.

Each chamber is adjusted to give equal voltage when combustion gases or smoke are nonexistent. Also, each chamber will continue to do so for an exceedingly long time, since the half-life of the radioactive material is approximately 1600 years. However, when combustion gases or smoke are present the balanced condition no longer exists. The chamber exposed to the atmosphere rapidly changes its condition, causing the tube to become electrically conductive, which, in turn, operates a relay in a space-indicating cabinet, if used, or the fire-indicating cabinet.

The pre-detector head is designed to be attached to a standard 4-in. round electrical conduit box and each one can be adjusted to its own sensitivity without affecting the others in the circuit. As many pre-detector heads as necessary can be connected together in a single two-wire circuit to the fire-indicating cabinet.

With a single circuit, the pre-detector heads are connected directly to the fire-indicating cabinet. When combustion gases or smoke are present, relays in the fire-indicating cabinet function to sound alarms, close fire doors, activate fire-extinguishing systems, or perform other fire-protection functions.

Can Locate Fire

Where it is desirable to know the location of the fire, a space-indicating cabinet can be connected through separate circuits, each circuit containing the necessary number of heads to cover specified locations. Up to four separate circuits can be connected to the fire-indicating cabinet, making a total of 16 separate circuits or spaces being handled by one system. The space-indicating cabinet shows visually by number the area affected and it contains relay contacts which will shut down ventilation, activate a fire-extinguishing system, or perform other functions in the affected space.

The important advantage cited for this system is the fact that invisible combustion gases as well as smoke

from fire, either of a slow smoldering nature or a fast free-burning nature, will sound an alarm. Furthermore, dust and soot cause only negligible changes in sensitivity; and low temperature or humidity is said to have no adverse effects on its operation.

Synthetic-Fuels Research

ACHIEVEMENTS during the tenth year of Bureau of Mines research under the Synthetic Liquid Fuels Act were reported to the Congress recently by Secretary of the Interior Douglas McKay.

High lights of the report, covering the calendar year 1954, are:

1 Installation by a chemical manufacturer of commercial-scale equipment for gasifying coal at atmospheric pressure. This equipment was developed on the basis of experiments performed at the Bureau's Morgantown, W. Va., laboratories.

2 Resumption of experiments at Gorgas, Ala., in co-operation with a number of private firms, to evaluate a hydraulic method of fracturing a coal seam so that it can be gasified underground.

3 Advancement of work at Bruceton, Pa., on a single-step process for making oil by the hydrogenation of coal, which may replace the present two-step process.

4 Continued operation of a 150-to-300-ton-a-day gas-combustion retort for oil shale at Rifle, Colo. During 1954 this retort was in operation 59 days without serious difficulty.

5 Progress in studies at Laramie, Wyo., on the fundamental structure of oil shale.

Coal Gasification

To permit conservation of power and reduction of costs in producing from coal raw materials for chemicals, synthetic liquid fuels, and pipe-line gas, the Bureau concentrated on efforts to develop a practical apparatus for gasifying coal under pressure. Work on atmospheric-pressure gasification was discontinued with industry's acceptance of this process.

Progress was made in research on purifying crude synthesis gas. More accurate evaluation of performance and improvement in design of dust-removal equipment was made possible through development of a method for determining the size of dust particles or agglomerates as they actually exist in a gas stream. To reduce gas-purification costs further, the Bureau joined with industry in pilot-plant tests of a new type of apparatus which promises more efficient removal of carbon dioxide and hydrogen sulphide.

Beginning in June, 1954, experimental facilities were transferred from various locations in and around Morgantown to the Bureau's new experiment station there.

Underground Gasification

Co-operative experiments in preparing unmined coal for gasification underground were resumed in June, 1954, when the Alabama Power Company, the Stanolind Oil and Gas Company, the Halliburton Oil Well Cementing Company, and the Bureau of Mines agreed to test a hydraulic process for fracturing a coal bed. The first trial resulted in a marked increase in coal-bed permeability, and much of the coal appears to have been affected.

Coal to Oil

The first pilot-plant tests of a single-step hydrogenation process developed in the Bureau's Bruceton laboratories gave nearly complete conversion of coal to heavy oil. However, since only small amounts of gasoline and gaseous hydrocarbons were obtained, and overheating caused trouble, the reactor was redesigned. Further tests will be made in 1955.

Researchers at Bruceton studied different methods of pretreating and activating catalysts for the Fischer-Tropsch gas-synthesis process, employing such materials as steel wool and alloy steels. Steel wool proved extremely active when oxidized. It was found also that steel turnings could be restored, as can other types of catalysts, by injecting an alcoholic solution of potassium hydroxide into the reactor.

Oil From Shale

To reduce the cost of mining oil shale, Bureau engineers at Rifle, Colo., designed a rotary-drill heading jumbo which can be used to drill horizontal holes in the face of a shale deposit.

Reduced heat losses and improved shale flow were achieved in the Bureau's 6-ton-a-day gas-combustion plant at Rifle by substituting an insulated stainless-steel vessel for the refractory-lined retort formerly used. Studies made in this small unit showed that secondary cracking, which causes retorting difficulties and interferes with oil yield, can be controlled by adding salt water to the raw shale.

The Bureau continued operation of the 150-to-300-ton-a-day gas-combustion retort at Rifle to find ways of improving oil yield at reasonably high rates of shale throughput. Progress was made in designing a practical device for injecting air into the retort to heat the shale. Work began on a report describing five years of thermal refining and chemical-treatment studies at Rifle.

On the basis of work the Bureau has done at Rifle, a private petroleum company is proceeding with plans for a large oil-shale pilot plant.

Research continued at Laramie, Wyo., on high-temperature retorting of small particles of shale in an entrained-solids system. A few experiments were made with air, instead of steam, as the entraining medium. Other studies showed that destructive hydrogenation is effective in removing such impurities as sulphur, nitrogen, and oxygen from shale oil.

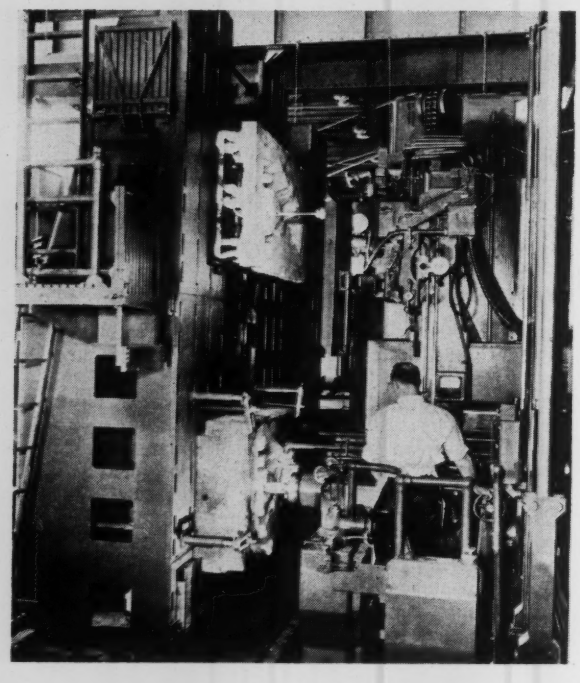
Powder-Metallurgy Manual

AN ENGINEERING manual on powder metallurgy has been published by the Amplex Division of Chrysler Corporation, Detroit, Mich.

Entitled "Engineering Manual E-55," the new 52-page book is liberally illustrated with photos, tables, charts, and graphs. Additional illustrative material is presented in the form of case histories involving the kind of information most pertinent for both actual and potential users of metal-powder parts.

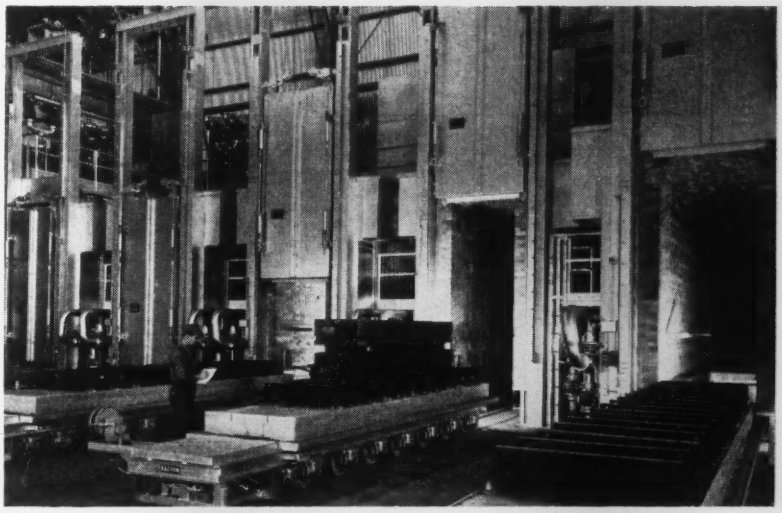
Separate sections in the manual are devoted to bearings, component parts, and filters. Other subjects include design, loads and speeds, installation, press fit, close-in, shaft clearance, wall thickness, tolerances, temperature change, lubrication, machining, hardening, magnetic properties, and flow rates.

Giant Hydraulic Forging Presses. The United States Air Force's Heavy Press Program became an operating reality May 5, 1955, in Cleveland, Ohio. With two giant hydraulic forging presses as the nucleus, U. S. Air Force Plant 47 became the first complete facility of the multimillion dollar Heavy Press Program to go into operation. The press in the foreground is capable of exerting up to 35,000 tons of forging pressure and was built by United Engineering and Foundry Company, Pittsburgh, Pa. The other press, shown in background, built by Mesta Machine Company, Pittsburgh, Pa., has a maximum forging force of 50,000 tons. Each press weighs more than 6000 tons. The presses and the millions of dollars' worth of auxiliary equipment required by them are located in a 12-acre aluminum-sheathed plant erected for the Air Force by Aluminum Company of America. Alcoa will operate the new plant under a lease arrangement with the Air Force. Primarily, Alcoa will use the presses and the plant to make huge light-alloy forgings for military aircraft. Size and pressure of the presses will establish new concepts in aeronautical design. And the presses open up broad fields for forgings in peacetime applications.

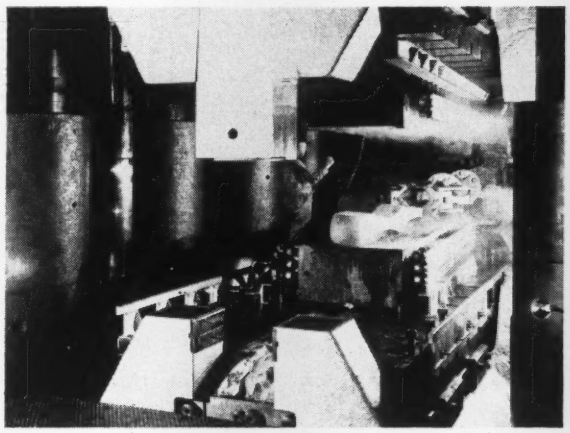


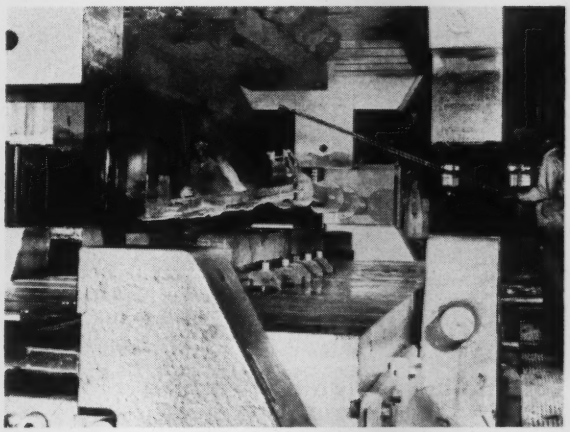
USAF Heavy Press Plant . . . . . Goes Into Operation

Die Sinking. One of the out-size tracer-controlled die-sinking machines installed in the Heavy Press Plant is shown cutting the forging impression into a die for one of the huge presses. A metal finger traces contours of a forging's plaster model (top of machine) and causes matching impression to be sunk automatically into the die block (lower part of photo). The die-sinking shop, equipped with the world's biggest machines for this purpose, is believed to be the largest ever built.



Die Preheating Furnaces. Before going into either the 35,000 or 50,000-ton presses, dies are heated to proper temperature for forging in this battery of five specially constructed car-bottom furnaces near the presses. Large furnaces are also available for heating the billets, and others are available for heat-treating the forgings after they have been hot-worked.





Forging Operation. A manipulator is shown at *left* putting a preformed billet on the dies of the 50,000-ton press for the first (blocking) forging operation on a wing spar. At *right*, the wing-spar forging is being removed from the press immediately after the first forging squeeze has been performed. Workman, *right*, is applying lubricant to the dies.

Forging Inspection. Immersed in water, these aircraft forgings are being inspected by the ultrasonic reflectoscope, one of the many quality checks Alcoa gives the products forged in the new Heavy Press Plant. The testing facilities which allow inspectors to maintain maximum quality control also include special checking machines, Zyglo, or black-light inspection, and Brinell-hardness test.

European Survey

Engineering Progress in the British Isles and Western Europe

J. Foster Petree,[1] Mem. ASME, *European Correspondent*

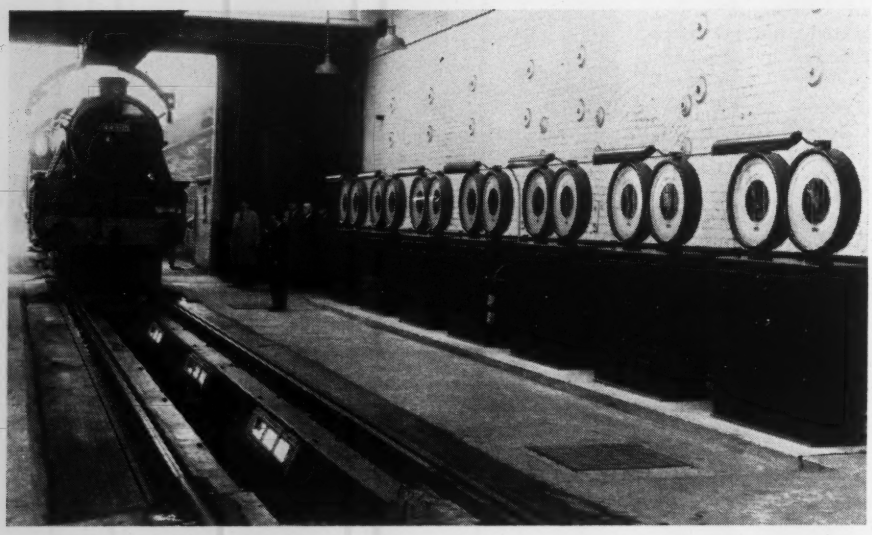


Fig. 1 View of a London Midland Region British Railways 4-6-0 Class 5 locomotive approaching the weighing machine

Locomotive Weighing Machine

British Railways have recently installed a new type of weighing machine, Figs. 1 and 2, at Crewe, which is one of their principal locomotive works. Constructed by Henry Pooley & Sons, Limited, Birmingham, England, it enables the weight on each wheel of a locomotive to be measured independently, so that the springs may be adjusted to insure that the total weight is distributed between the wheels in the correct proportions. The weighbridge consists of 14 separate tables, in seven pairs each 7 ft long, with no "dead" sections between them. The total weighing capacity is 280 tons. The weighbridge is contained in a cast-iron frame of very rigid construction, the joints and all meeting surfaces being machined and the parts secured together by fitted bolts. The brackets carrying the main levers are cast integrally with the frame. The tables are specially designed to prevent tipping when the wheels bear upon the ends of the weigh rails, in coming on and going off as well as when weighing. The main levers of the tables are of cast iron and are fitted with steel knife-edges, hardened and lapped, and secured by wrought-iron shanks into recesses machined in the levers. The rockers are of mild steel, with hardened-steel bearings for supporting the fulcrum knife-edges of the main levers. All knife-edges and bearings are interchangeable throughout the 14 tables. The weigh rails are provided with check rails to insure that each pair of wheels on its axle is symmetrically disposed when weighing, i.e., with equal clearances between the wheel flanges and the weigh rails. The indicators, one for each wheel, are entirely mechanical in their action, no fluid being used to transmit the load. The dials, which are illuminated by fluorescent

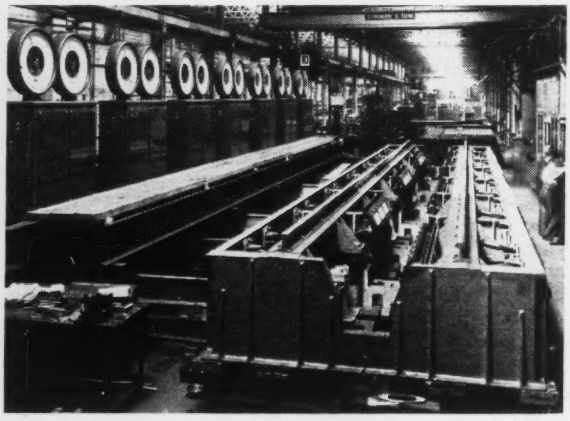


Fig. 2 Over-all view of new locomotive weighing machine

[1] Correspondence with Mr. Petree should be addressed to 36 Mayfield Road, Sutton, Surrey, England.

lighting, are graduated to 20 tons in divisions of 1 hundredweight (112 lb), but the apparatus is much more sensitive than this, the pressure of a man's foot on a rail being sufficient to move the pointer. The position of the pointer can be adjusted to zero from outside the case of the indicator, and the mechanism of all 14 indicators can be put out of engagement instantly by moving a single lever, to prevent oscillation while a locomotive is moving onto and off the tables. The platform plating is removable in sections, without disturbing any of the gear, to give access to the weighing mechanism; and a central walkway between the rails, in a pit 2 ft 6 in. deep and fitted with fluorescent lighting, enables the springs of the locomotive to be adjusted during the balancing operation, in accordance with the readings on the dials. The weighing machine is housed in a building erected for the purpose, with sliding doors at each end, and provided with roof vents and excellent natural and artificial lighting.

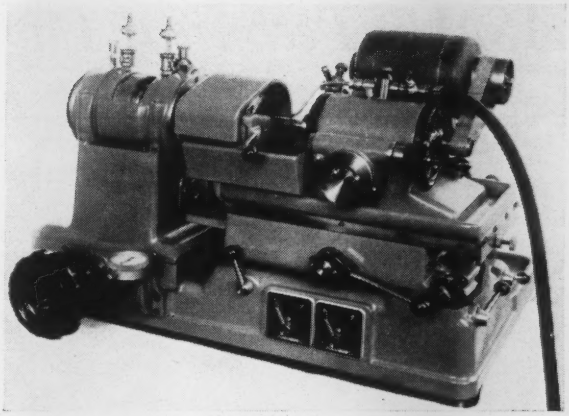


Fig. 3 Special-purpose grinding machine for film punches

Film-Punch Grinding Machine

THE perforations in cinema film are usually made by a tool consisting of four punching plates joined together, each having two pairs of punches on it. As the distances between the holes must be maintained within a very close tolerance, the punches must be made with corresponding precision. Negative and positive films have different perforations. Those of a negative film have two long parallel sides, joined at the ends by arcs of a circle struck from the geometrical center of the hole. Those of a positive film are in the form of a rectangle with its four corners rounded to a radius equal to about a quarter of the lesser width of the hole. The two parallel faces of a negative punch are readily ground on a surface grinder, and the two rounded ends on a cylindrical grinder, with the punch held in a special clamp. The two pairs of parallel faces of a positive punch are also finished on a surface grinder quite simply, but the work must be positioned afresh to grind each of the four rounded corners, grinding being effected by swinging the punch through 90 deg round the center from which each radius is struck; this is an operation requiring considerable time, and great skill on the part of the operator.

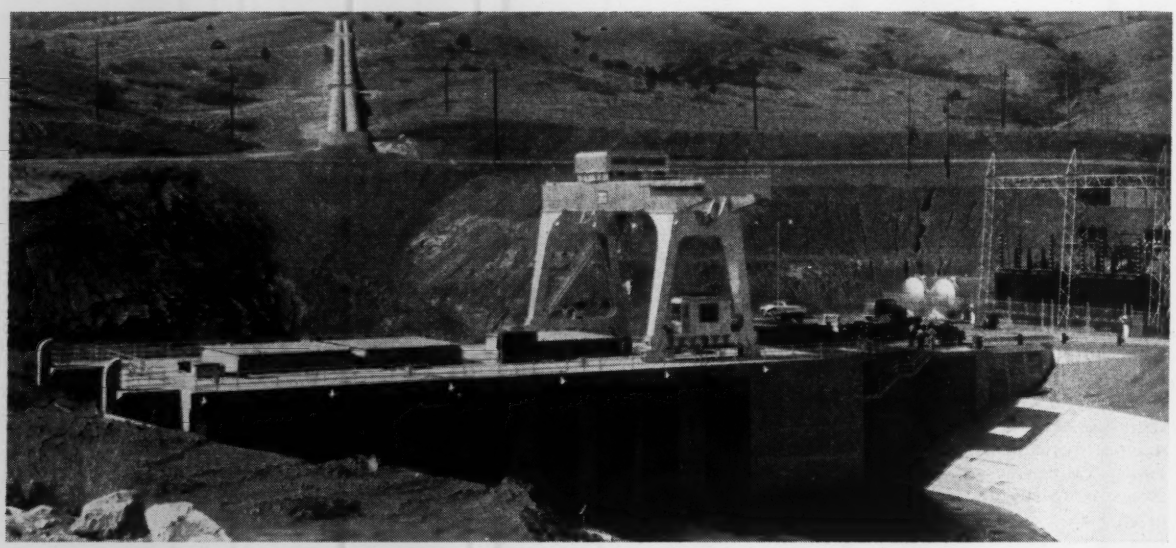
To simplify this operation, the firm of F. Studer Maschinenfabrik of Glockenthal-Thun, Switzerland, have brought out a special-purpose grinding machine known as the Type LSSM, Fig. 3. In this machine the work spindle is supported in a rocker which carries a cam of the same form as that of the punch to be ground, but of larger size. The axis of the work spindle is parallel with that of the rocker but is 6 mm above it; so that, the axes of the cam and the rocker being 120 mm apart, there is a ratio of 20:1 in size between the shape of the cam and that of the finished punch. The cam is driven from the work spindle through toothed gearing and rolls on a segmental plate submerged in an oil bath, being held in contact with it by a spring. The motor and drive for the workpiece are mounted on the cross slide, and the transverse feed, which can be checked by a dial-gage reading to 0.001 mm (0.00004 in.), is controlled by a handwheel. The base plate carrying the grinding slide can be swiveled through 5 deg to each side for grinding punches of tapered form. The slide is withdrawn to introduce the workpiece, and then advanced to engage with the work, by means of a hand lever, its travel being limited by an adjustable screwed stop. The work is held in a clamping device attached to a faceplate on the work spindle. This clamp is so designed that, by reversing it on the faceplate, all four punches in turn can be brought into line with the axis of the work spindle, without removing the punch plate from the clamp. The internal grinding spindle is guided in a bush in the grinding head and is driven at 10,000 rpm by a single-phase slip-ring motor. For truing the grinding wheel, the machine is fitted with a diamond holder which can be swung back when not in use. When truing the wheel, the grinding spindle is moved axially through worm gear by means of a handwheel. Coolant is delivered by an electrically driven pump, mounted on a separate tank which contains a smaller settling tank.

The Late Engineer Captain Edgar C. Smith

MARINE engineering, and naval engineering in particular, has lost a notable historian by the death on March 13 of Engineer Captain Edgar Charles Smith, Royal Navy. Captain Smith, who was 82 years of age, entered the British Navy in 1895 as an Assistant Engineer (a grade now obsolete) and saw service in many parts of the world, in battleships, cruisers, destroyers, and several of the British naval dockyards, between then and his retirement in 1922. From an early age he had been interested in the history of science and technology, and, when he retired, set himself to collect all available first-hand and recorded information, from older engineers and their families, and from official records, many of which had never been studied previously in any detail. From these sources he built up a remarkable store of authentic historical data, which formed the basis of a long series of papers and of articles in technical and scientific journals. He was President in 1937–1938 of the Newcomen Society for the Study of the History of Engineering and Technology, and contributed extensively to its Transactions on marine engineering and the development of steam navigation across the Atlantic. An active and vivid correspondent, he had many professional friends in the United States and among the members of ASME, including the late Sanford Riley of Worcester, Mass., in whose Riley Stoker Corporation Captain Smith's eldest son, Eric H. Smith, is now a chief engineer.

ASME Technical Digest

Substance in Brief of Papers Presented at ASME Meetings



General view of Flatiron Power and Pumping Plant. The plant is a semi-indoor installation consisting of a reinforced concrete structure which rests on siltstone, claystone, and sandstone. The main powerhouse crane of 100-ton capacity is mounted in a roof deck. The combination plant contains two 48,000-hp Francis-type turbines and one reversible pump-turbine, motor-generating unit.

Hydraulics

Design Features of the Flatiron Power and Pumping Plant, by John Parmakian, Mem. ASME, Bureau of Reclamation, U. S. Department of Interior, Denver, Colo. 1955 ASME Spring Meeting paper No. 55—S-30 (multilithographed; available to Feb. 3, 1956).

THE Flatiron Power and Pumping Plant is the largest and the terminal plant which utilizes the power drop in the transmountain water-diversion system of the Colorado-Big Thompson Project. This completed project is a recent Bureau of Reclamation development which diverts water from the Colorado River on the western slope of the Continental Divide through the 13-mile-long Adams Tunnel to the eastern slope. It provides irrigation, hydroelectric power, and other benefits for a large area northeast of Denver, Colo.

The plant structure is a semi-indoor installation. It consists of a reinforced-concrete structure which rests on siltstone, claystone, and sandstone. The roof is located high above the bed of the creek and is above any flash flood that is expected to occur in this locality. The main powerhouse crane of 100-ton capacity is mounted on the roof deck.

This combination plant contains two 48,000-hp Francis-type turbines and one reversible pump-turbine, motor-generator unit. The two main generating units have a combined hydraulic capacity of approximately 960 cfs and operate under a maximum static head of 1118 ft.

This paper describes the design features of the generating units at the plant. It includes a description of the 48,000-hp Francis-type turbines, and the large 2-speed reversible pump-turbine motor-generator unit.

Performance Characteristics of Francis-Type Pump-Turbines, by W. J. McCormack, Assoc. Mem. ASME, S. Morgan Smith Company, York, Pa. 1955 ASME Spring Meeting paper No. 55—S-45 (multilithographed; available to Feb. 1, 1956).

ADVENT of single reversible pump-turbines in recent years for utilization in pumped-storage projects has aroused considerable curiosity among operating companies and consulting engineers regarding the general hydraulic characteristics of these machines.

This paper discusses some general hydraulic characteristics of developed Francis-type pump-turbines in order to assist engineers in designing and evaluating proposed installations.

Complete performance and cavitation characteristics are presented together with an illustrative example showing how to select the optimum unit for a given set of operating conditions.

Data used in this study were obtained from some developed S. Morgan Smith units that have been model-tested, as well as from published information of other manufacturers.

No definite rules or standards can be given for the application of pump-turbines to various hydraulic conditions, the paper concludes. Each application must be treated as a special problem, with the final selection of a particular design depending upon careful evaluation of the various factors involved.

It therefore becomes apparent that the

size, speed, elevation of volute center line, and other hydraulic characteristics for specified conditions will vary from one manufacturer to another. These items should be left open in the customer's specifications. However, an approximate range of speeds and settings may be selected from information supplied in the preliminary stages by the various manufacturers or from the curves presented in this paper. The purchaser must then evaluate the various units offered to select the one best suited to his operating requirements.

An Extension of the Theory of Water Hammer, by R. Skalak, Columbia University, New York, N. Y. 1955 ASME Spring Meeting paper No. 55—S-18 (multilithographed; to be published in Trans. ASME; available to Feb. 3, 1956).

THE usual theory of water hammer which is used to compute the magnitude and velocity of pressure waves in a pipe filled with an elastic fluid was given by Joukowsky in 1898. This theory predicts that pressure waves travel without change of shape.

In the present paper, water-hammer waves are considered without some of the simplifications made in the Joukowsky theory. The equations of motion for a thin cylindrical tube are used. Only the case where the velocity of sound in the material of the pipe wall is greater than in the fluid is considered. Much of the analysis would be valid in the opposite case, but the relative speeds of the various waves would differ.

Water Tunnels for Hydraulic Investigations, by J. M. Robertson, Mem. ASME, University of Illinois, Urbana, Ill. 1955 ASME Spring Meeting paper No. 55—S-19 (multilithographed; to be published in Trans. ASME; available to Feb. 3, 1956).

THE water tunnel is defined as a device similar to a wind tunnel for cavitation and other hydraulic testing.

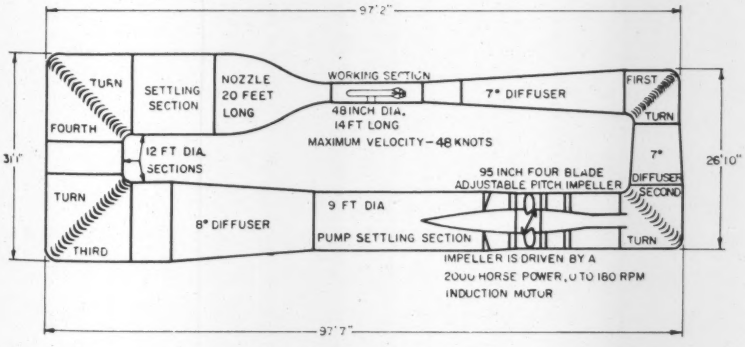
A list is presented of tunnels in the United States, and the various types of tunnels are described. Cavitation, the principal phenomenon of interest in most water-tunnel researches, is discussed and its scaling factor defined. The purposes and uses for which water tunnels have been built or employed are reviewed.

A bibliography on cavitation and water tunnels is included.

Design of Optimum Clearances in Positive-Displacement Pumps and Motors, by W. E. Wilson, Mem. ASME, The Pennsylvania State University, University Park, Pa. 1955 ASME Spring Meeting paper No. 55—S-4 (multilithographed; to be published in Trans. ASME; available to Feb. 3, 1956).

SINCE the efficiency of a positive-displacement pump or motor depends, to a great extent, upon the slip flow and the drag developed by moving surfaces, it is essential to proportion slip passages in such a manner that the energy losses are kept to a minimum. In this paper the slip flow and the drag on the moving elements are determined on the basis of a theory of laminar flow which takes into consideration the internal heating of the liquid and consequent reduction in viscosity. The optimum clearance, under various operating conditions, is determined.

It is shown that under certain circumstances the optimum clearance is not materially different from that predicted by the constant-viscosity theory. Under other circumstances the minimum clearance that is physically possible is shown to be the optimum.



Circuit diagram of 48-in. ordnance-research-laboratory water tunnel at The Pennsylvania State University showing design details and principal dimensions. It is not specifically a propeller tunnel, but can test propellers in the free-stream condition as large as can be tested in any other tunnel.

Nuclear Engineering

Zirconium-Fabrication Techniques and Alloy Development, by C. E. Lacy and J. H. Keeler, General Electric Company, Schenectady, N. Y. 1955 ASME Spring Meeting paper No. 55—S-43 (multilithographed; to be published in Trans. ASME; available to Feb. 3, 1956).

DURING the past five to ten years the technology and large-scale production of ductile zirconium metal has undergone a rapid development. This development has been due chiefly to interest in this metal for nuclear-reactor applications.

Zirconium has a combination of properties which particularly suit it for use as a structural material in nuclear reactors. These include a tendency to absorb relatively few neutrons, a high melting point, fair strength, and good corrosion resistance in water and liquid metals. A minimum tendency to react with and absorb neutrons is an additional characteristic required of metals to be used in the active core of reactors.

Fabrication techniques by which zirconium and its alloys have been successfully made into various product forms are described.

The neutron-absorption characteristics, mechanical properties, and corrosion resistance of zirconium and some zirconium alloys are discussed.

Shielding Concepts for Nuclear Reactors, by H. E. Stone, Assoc. Mem. ASME, General Electric Company, Schenectady, N. Y. 1955 ASME Spring Meeting paper No. 55—S-20 (multilithographed; available to Feb. 3, 1956).

THIS paper is an introduction to the problems associated with the shielding of nuclear reactors.

All types of radiation present in nuclear reactors and their shields must be reduced by the shield to acceptable levels. Radiation of different types, neutrons and gamma rays (high-energy x rays), can be added in their biological effect and the sum must not exceed the AEC tolerence of 0.3 rem/week.

All major sources of radiation encountered in reactor shields are discussed.

Three types of shields are mentioned:

1 The unit shield—for land-based reactors where weight and space are not of prime importance.

2 The compartment shield—used in mobile reactors where a radioactive coolant and heat-transfer equipment are in a shielded area to reduce the total shield weight and size.

3 The divided shield—which is the

lightest of the three but results in a large unshielded area between the reactor and personnel compartment.

The three processes for reducing the number and intensities of gamma and neutron radiation are explained. It is shown that neutrons require a light shield containing hydrogen (oil or water) while gamma rays need a heavy shield made of lead, for example. A good shield design must contain neutron and gamma-shielding materials and is, therefore, made up of oil or water plus steel or lead properly spaced.

Selection of Materials for a Sodium-Graphite Reactor System, by C. C. Woolsey, Jr., North American Aviation, Inc., Downey, Calif. 1955 ASME Spring Meeting paper No. 55—S-16 (multilithographed; available to Feb. 3, 1956).

CRITERIA are discussed for the selection of materials for components of a sodium-cooled, graphite-moderated reactor being constructed to study this type of system as a potentially economic one for a large-scale nuclear power plant.

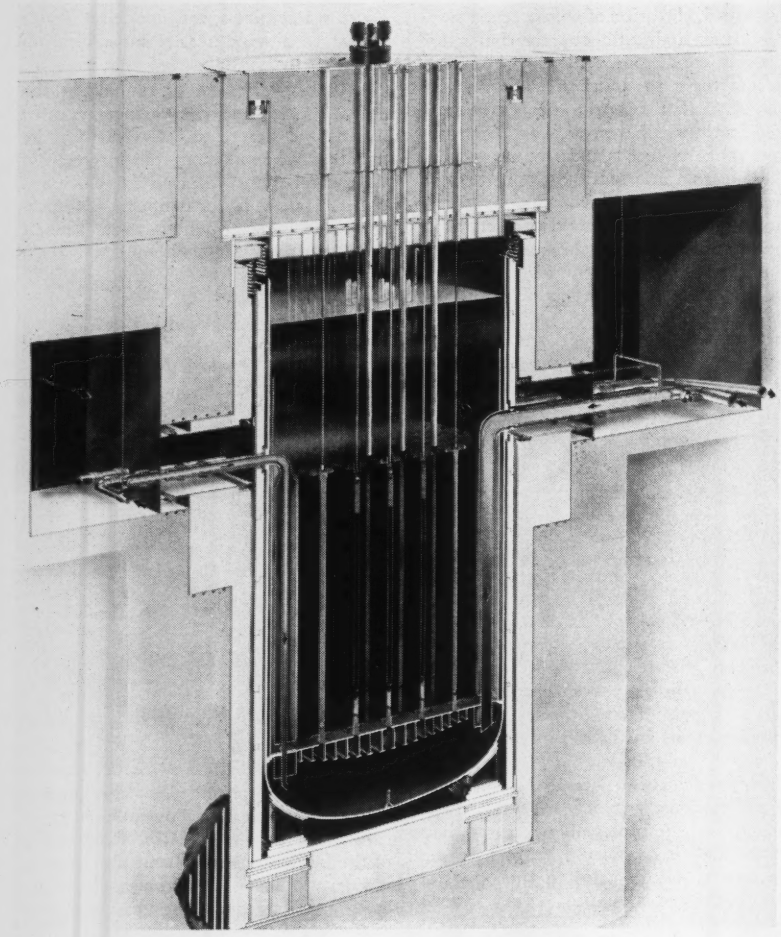
Discussion is limited to those materials in contact with the sodium coolant up to temperatures as high as 1200 F, both in the high-radiation field existing within the reactor core, and in the piping and heat exchangers external to the core. Materials involved are zirconium and stainless steels. Selection criteria include the usual high-temperature considerations of strength and compatibility with other materials in the system, and also their parasitic neutron absorption.

The Use of Benzene as a Thermodynamic Working Fluid for a Nuclear Power Plant, by I. G. McChesney, Mem. ASME, Rochester Gas and Electric Corporation, Rochester, N. Y., and R. H. Shannon, Mem. ASME, United Engineers and Constructors, Inc., Philadelphia, Pa. 1955 ASME Spring Meeting paper No. 55—S-29 (multilithographed; available to Feb. 3, 1956).

A FEASIBILITY study of benzene as a thermodynamic fluid for the fast-breeder reactor is presented. The study was conceived as a possible means of eliminating sodium-water-reaction hazards. Material presented should be of interest to anyone concerned with studies of fluids for use as thermodynamic working media.

It is felt that the use of benzene as the thermodynamic working fluid is not warranted for the following reasons:

1 Even though actual plant cost data were not developed, it appears that a benzene plant may well be as expensive as the combined cost of the steam plant and the NaK coolant system.



Sectional view of sodium-reactor. The reactor core is contained within a tank surrounded by shielding, all below ground level. Sodium is pumped to the lower chamber of the tank, upward through the reactor core to the upper chamber, then out to primary heat exchangers located in galleries external to the reactor itself. A secondary sodium system transfers the heat from the primary heat exchangers to the sodium-to-air heat exchangers. If a power-generating plant were to be included, the latter heat exchangers would be replaced with boilers for producing the steam necessary to drive the turbines.

2 Use of benzene involves additional hazards in the operation and maintenance of the plant. It is true that hydrogen-cooled generators are operated satisfactorily. However, the benzene hazard would be much more severe due to the large number of pieces of equipment, valves, and piping systems in the benzene power plant.

3 Potential danger of moderating elements, carbon and hydrogen, getting into the sodium coolant still exists with the use of benzene—thus resulting in an extremely hazardous condition with a fast neutron reactor.

4 Undesirability of having to tie the development of a benzene power plant in with the development of a nuclear reactor.

Metals Engineering

Testing of Small-Diameter Tubing With Automatic Recording Ultrasonic Equipment, by W. L. Fleischmann, Mem. ASME, and H. A. F. Rocha, General Electric Company, Schenectady, N. Y. 1955 ASME Spring Meeting paper No. 55—S-23, (multilithographed; to be published in Trans. ASME; available to Feb. 3, 1956).

THIS paper presents the progress made in the ultrasonic test equipment which now appears to make automatic testing of small-diameter tubing a distinct possibility. It presents some cross sections, showing the type and size of discontinuities detected with this equipment in Type 347 stainless-steel tubing.

The paper points out the inherent difficulties in judging the severity of the

defect by the amplitude indications alone and the importance of the experience factor which is required to interpret the test results.

Ultrasonic Attenuation Measurements for Study of the Engineering Properties of Materials by R. Truell, Brown University, Providence, R. I. 1955 ASME Spring Meeting paper No. **55—S-17** (multilithographed; available to Feb. 3, 1956).

THIS paper discusses a relatively new method of studying the physical properties of materials. It is a method which is being used for fundamental work in the physics of solids, and which has been of interest to a few physicists for sometime.

It can be used in metallurgy, and in quite a few engineering applications of both fundamental value and of immediate practical value including a number of quality-control applications. It is these possible applications that the author has in mind.

The method is sufficiently new so that the results and interpretation of the results are still in the early stages of development. Nevertheless, many of the fundamental features are clear.

Utilization of Data Obtained in Sonic Tests of Plain Concrete, by C. E. Kesler and T. S. Chang, University of Illinois, Urbana, Ill. 1955 ASME Spring Meeting paper No. **55—S-3** (multigraphed; available to Feb. 3, 1956).

AN algebraic equation and nomograph are presented in this paper for the prediction of compressive strength of concrete from its sonic properties.

Magnitudes of the sonic properties were found to depend not only on the age and curing of the specimen but also on the size of the specimen.

An empirical method is presented to convert sonic properties of concrete specimen of any size to those expected of a standard 6-in. × 12-in. cylinder.

An Evaluation of Brass-Powder Structural Parts in Product Engineering, by G. L. Werley, The New Jersey Zinc Company, Palmerton, Pa. 1955 ASME Spring Meeting paper No. **55—S-39** (multilithographed; available to Feb. 3, 1956).

DOMESTIC production of metal parts from powder is not new. Oilless bearings, for example, have been pressed from powder with great success since the early 1920's. However, the currently expanding use of metal-powder structural parts is definitely in the new category.

Product engineers are now seeking more information as to which powders can be pressed and sintered, what the specific design considerations are, what physical and mechanical properties can be expected, and where such parts can be employed. This paper attempts to supply basic information on the subject.

Steam Power Generation

Rotary Regenerative Heaters for Shipboard Installations, by W. E. Hammond, Mem. ASME, Air Preheater Corporation, Wellsville, N. Y., R. P. Giblon, George G. Sharp, Inc., New York, N. Y. and C. E. Hoch, U. S. Navy Department, Washington, D. C. 1955 ASME Spring Meeting paper No. **55—S-32** (multilithographed; available to Feb. 3, 1956).

THE rotary-type regenerative air preheater might be simply described as a device that accomplishes continuous counterflow heat exchange between flue gas and combustion air. Heat is transferred by means of the high-efficiency, slowly rotating heating element—compact—light.

Regenerative air preheaters are available for marine service as well as for stationary service, in designs for either vertical or horizontal flow of gas and air streams. For vertical flow, the direction of either stream may be upward or downward; for highest effectiveness gas and air flow counter to each other.

The essence of the regenerative-type heat exchanger is the heating element. In the regenerative air preheater, the heating elements are contained in a slowly turning rotor of cellular construction. As the rotor turns, heat is absorbed continuously by the heating elements from the flue gas, while a like amount of heat is released simultaneously to the combustion air, as these fluids flow axially through the rotor. The rotor is enclosed in a gastight housing, which is fitted at either end to make connection with the air and flue-gas ducts.

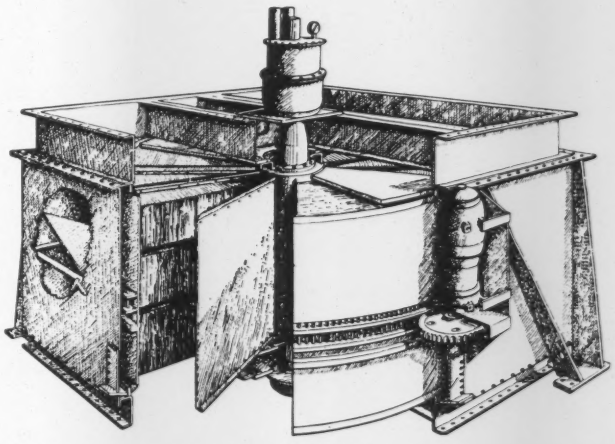
In selecting heat-recovery equipment for marine boilers, the authors believe that in addition to the fuel savings realized by using regenerative air heaters there is a significant additional saving realized through reduced maintenance. High-temperature combustion air reduces the formation of SO_3. It insures the complete combustion in the furnace, particularly in small marine-type furnaces and thus reduces the influence of carbon in the cold-end corrosion phenomena.

In citing experience in this country in marine applications, the authors have confirmed British experience regarding the suitability of this equipment aboard ships.

Comparison of Design and Service Performance of Some Modern Tankers, by J. A. Britton and E. H. TenBroeck, Mem. ASME, Atlantic Refining Company, Philadelphia, Pa. 1955 ASME Spring Meeting paper No. **55—S-37** (multilithographed; available to Feb. 3, 1956).

THIS paper presents a comparison of design versus service performance of the several types of power plants in the tankers of the Atlantic Refining Company's fleet.

Tables are presented showing the design, original and normal operating performances. The value of instruments



Typical rotary regenerative heater for marine service. The heating elements are contained in a slowly turning rotor of cellular construction. As the rotor turns, the heat is absorbed continuously by the heating elements from the flue gas, while a like amount of heat is released simultaneously to the combustion air, as these fluids flow axially through the rotor.

in locating and correcting sources of loss is emphasized.

A brief discussion of experience with the major units of machinery is given.

Significance of Slime in Causing Corrosion and Mechanisms of Corrosion by Slime Growth, by R. S. Wise, National Aluminate Corporation, Chicago, Ill. 1955 ASME Spring Meeting paper No. 55—S-40 (multilithographed; available to Feb. 3, 1956).

CORROSION rate is increased by bacteria in cooling-tower systems by a combination of several mechanisms. The total corrosion rate in the presence of slime may easily be double that in the absence of slime.

This paper outlines the ways in which bacterial corrosion can take place in cooling-tower systems, and presents data under laboratory-controlled conditions to illustrate the degree of corrosion which may be expected from this source.

The Treatment of Condenser Circulating Water, by Andrea Iorio, Mem. Societa Meridionale Elettricita, P. E. Imbriani, Naples, Italy. 1955 ASME Spring Meeting paper No. 55—S-49 (multilithographed; available to Feb. 1, 1956).

AFTER a few considerations of the degree of cleanliness of condenser tubes, this paper takes up examination of the effects of condenser water on the tubes and on the inlet equipment. They are considered under the double aspect of incrustation and corrosion.

Reference is particularly made to the investigations conducted at the thermoelectric centers "Maurizio Capuano" and "Vigliena" of the Societa Meridiana di Elettricita to study the nature and behavior of incrustations and corrosion caused by the use of salt water from the Naples Harbor. Corrective measures are also discussed.

Control of Slime and Marine Fouling, by S. A. Cole, Mem. ASME, Wallace & Tiernan, Inc., Belleville, N. J. 1955 ASME Spring Meeting paper No. 55—S-48 (multilithographed; available to Feb. 1, 1956).

THIS paper covers modern slime and marine-growth-control practices using chlorination.

The value of free chlorine residuals, time of contact, magnitude of residual, and frequency of treatment are discussed. Unusual case histories are presented to illustrate the influence of various external factors on chlorine treatment—for example, the presence of ammonia.

Mechanical problems in connection with the installation of equipment, selection of points of chlorine application, diffusor design, and the like, are discussed as applied to modern power-plant cooling-water systems.

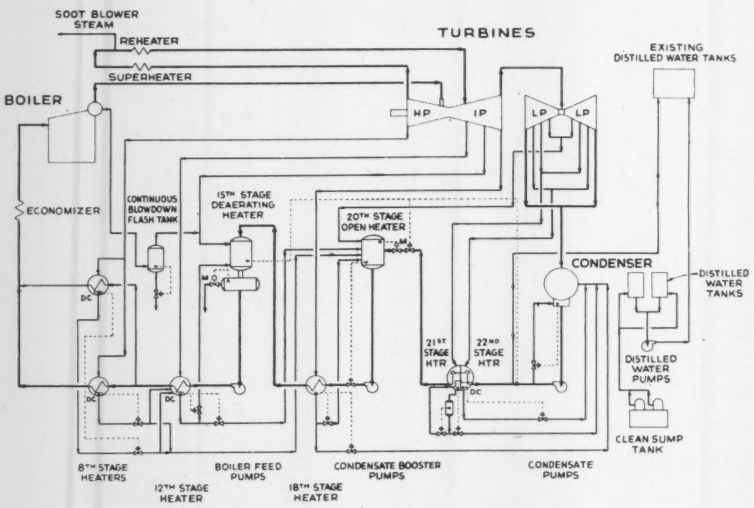
Design Features, Operating Experience, and Performance of 100,000-Kw Reheat Installation at Potomac River Station, by L. W. Cadwallader, Mem. ASME, Potomac Electric Power Company, Washington, D. C., and H. S. Frederick, Mem. ASME, Stone and Webster Engineering Corporation, New York, N. Y. 1955 ASME Spring Meeting paper No. 55—S-21 (multilithographed; to be published in Trans. ASME; available to Feb. 3, 1956).

THIS paper discusses outstanding design features, operating experience, manpower requirements, and performance record of a generating unit with a design capability of 100,000 kw and with steam conditions of 1800 psig pressure, 1050 F primary steam temperature, and 1000 F reheat steam temperature. This design capability of 100,000 kw is somewhat less than the national average of 124,000 kw for all reheat machines purchased in the past six years. Initial steam pressure and temperature have been surpassed by other installations, and condenser circulating-water temperature is relatively high, with maximum temperatures of 88 F and a four-month average of 81 F for June to September, inclusive. Notwithstanding these basic limitations, the over-all thermal efficiency is averaging 37 per cent which is near optimum for conditions below the supercritical.

The unit under discussion is the No. 3 unit in a station housing also two 90,000-kw nonreheat machines placed in operation in October, 1949, and June, 1950. The new No. 3 unit was placed in preliminary operation June 30, 1954, and became firm commercial capacity two weeks later, on July 14, 1954. Unit No. 4, which is a duplicate of No. 3, is under construction and is scheduled for service early in 1956. There is a single boiler per turbine, and fuel used is pulverized coal. Light fuel oil is used for ignition.

Sealing Regenerative-Type Air Preheaters for High-Pressure Differentials, by G. D. Braddon, Mem. ASME, T. L. Woolard, Mem. ASME, and E. P. Horn, The Air Preheater Corporation, Wellsville, N. Y. 1955 ASME Spring Meeting paper No. 55—S-41 (multilithographed; available to Feb. 3, 1956).

THE rotary regenerative type of heat exchanger makes it possible to utilize heating surface more advantageously than in other types. This is due to the fact that short flow lengths can be utilized while still maintaining pure counterflow heat exchange. To date the full advantages of this heat exchanger have not been exploited owing to the fact that present seals have limited its application to the relatively low-pressure ranges. These economic advantages make it essential that improved sealing means be developed so that they may be applied to gas-turbine applications and future boiler applications which do in-



Fundamental flow diagram of No. 3 unit of the Potomac River Generating Station. The unit has a design capability of 100,000 kw, 1800 psig pressure, 1050 F primary steam temperature, 1000 F reheat steam temperature, seven stages of extraction feedwater heating with a maximum feedwater temperature of approximately 450 F entering the boiler economizer.

volve higher pressure differentials. Accordingly, the authors' company undertook an investigation program to develop new types of seals. To date, the results of this investigation have been exceedingly encouraging and seals will be available for both applications.

This paper reports progress in the concerted program to develop seals for the regenerative heat exchanger to advance its use for higher-pressure applications.

An Approach to the Economic Problem of Matching Condenser Surface With Exhaust-Annulus Area, by W. A. Wilson, Mem. ASME, Massachusetts Institute of Technology, Cambridge, Mass., and L. G. Malouf, formerly with Convair, Fort Worth, Texas. 1955 ASME Spring Meeting paper No. **55—S-31** (multilithographed; to be published in Trans. ASME; available to Feb. 3, 1956).

THE concept of economic balance as related to power-plant optimization is discussed. Its application to the problem of choosing appropriate exhaust-annulus and condensing-surface areas is developed in detail. These areas are related to each other for three circulating-water temperatures and several unit-cost ratios. The exhaust conditions and the rate of change of stagnation enthalpy with investment are presented as functions of these areas.

Machine Design

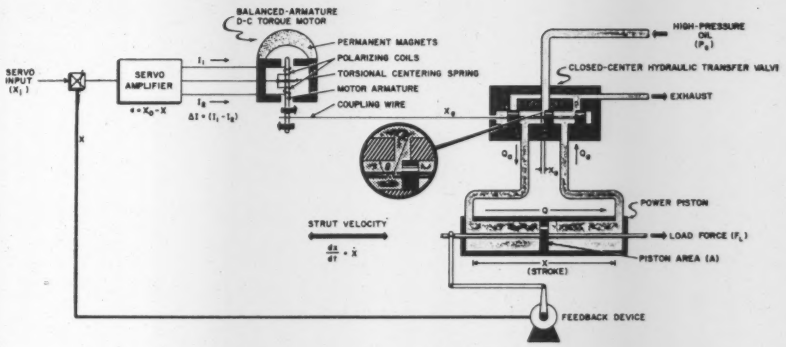
A Method for the Selection of Valves and Power Pistons in Hydraulic Servos, by F. C. Paddison and W. A. Good, The Johns Hopkins University, Silver Spring, Md. 1955 ASME Spring Meeting paper No. **55—S-10** (multilithographed; available to Feb. 3, 1956).

AN analysis was made of hydraulic servo systems to determine a method of selecting transfer valves and power pistons that will give the optimum oil-pressure distribution within a servo. Two valve types were considered:

1 Those in which the oil flow is independent or nearly so of the reaction (Bernoulli) forces within the valve. In this type the rate of oil flow is a function of the pressure across the valve.

2 Those in which the oil flow is not independent of the reaction forces. The valve may use these forces to effect a compensation such that the oil-flow rate is reasonably independent of the pressure across the valve.

It was found that a valve should provide the required power-piston speed at full load with a valve pressure drop of one third the supply pressure. Correspondingly, the power-piston area should



Diagrammatic sketch of a typical closed-loop hydraulic servo system

be selected with a pressure drop of two thirds the supply pressure assumed across the piston. The efficiency of such a servo is 66 per cent. A valve pressure drop of less than one third the supply pressure may reduce oil consumption if flow limiters are used, but such a choice may result in increased overlap and dead-space difficulties, since it allows a large gain change between the full-load and no-load conditions. A valve pressure drop of greater than one third the supply pressure reduces the gain change between the full-load and no-load conditions, but consumes more oil.

A mechanism for gain compensation was also studied. It was found that the best result is achieved with a design pressure drop across the valve of one third the supply pressure.

Surface Roughness and the Design Engineer, by Joseph Manuele, Affiliate Mem. ASME, Westinghouse Electric Corporation, Pittsburgh, Pa. 1955 ASME Spring Meeting paper No. **55—S-11** (multilithographed; available to Feb. 3, 1956).

THIS paper attempts to explain some of the more important features of the proposed American Standard for Surface Roughness, Waviness, and Lay. It also shows how the Standard may be used by the engineering department to determine surface-roughness values and the importance of choosing the proper instrument for measuring surface roughness.

Contributions to Hydraulic Control—VII, Analysis of the Effects of Nonlinearity in a Valve-Controlled Hydraulic Drive, by E. I. Reeves, Massachusetts Institute of Technology, Cambridge, Mass. 1955 ASME Spring Meeting paper No. **55—S-9** (multilithographed; available to Feb. 3, 1956).

A METHOD is developed for analyzing the performance of a valve-controlled hydraulic drive consisting of a closed-center four-way valve, hydraulic motor, and mechanical load. This analysis facilitates the determination of the amplitude and phase of the fundamental component of load velocity in response to sinusoidal valve-spool motion and includes the effects of three sources of nonlinear performance: The pressure-flow characteristics of the valve, orifice-type hydraulic leakage, and nonlinear speed-dependent friction.

The analysis is verified by analogue-computer results and experimental data from an actual valve-controller drive.

Method of Filling Up a Reel at a Constant Rate of Feeding, by Stephen Kulik, University of South Carolina, Columbia, S. C. 1955 ASME Spring Meeting paper No. **55—S-12** (multilithographed; available to Feb. 3, 1956).

IF a cap moves up and down at a constant speed and yarn is delivered at a constant rate, the amount of yarn wound up between any two equidistant cross sections of the bobbin is constant. If the speed is variable, the amount of yarn is less at the points where the speed is higher. The final shape of the bobbin when filled with yarn can be achieved by choosing the shape of the barrel of the empty bobbin and the speed of the movement of the cap.

The way in which thread is put on a bobbin is of importance when yarn is unwound. If it is done by pulling the thread over the top end of the bobbin, the lower layers of yarn should not hamper the free sliding of the thread from the upper layer.

It is assumed in this paper that yarn is delivered to the bobbin at a constant rate per unit of time. Two cases are considered. The first case is when the feeding end of the thread makes strokes along the entire bobbin, from the bottom to the top and back. A formula is derived

for the speed of strokes for a given shape of an empty bobbin and the desired final shape of the filled-with-yarn bobbin.

This case is introductory to the second case in which the length of strokes is variable. The cap on the bobbin makes one movement from the bottom of the bobbin to a definite point on it and back, so that the feeding end of the thread makes its shortest stroke up and down. Next time the cap moves to a higher point on the bobbin and back and so on until it makes its longest stroke from the bottom to the top of the bobbin. The length of the strokes is regulated by the movement of a shortening device which moves from the position at which the cap makes its shortest stroke to the position when the cap makes its longest stroke. The speed with which the length of strokes vary, or what is the same, the speed of movement of the shortening device, is derived.

The theory is supplemented by two simple examples for illustration. In practice the equations involved are more complicated.

Metal Processing

Heavy-Duty Machining, by A. B. Albrecht, Monarch Machine Tool Company, Sidney, Ohio. 1955 ASME Spring Meeting paper No. **55—S-42** (multilithographed; available to Feb. 3, 1956).

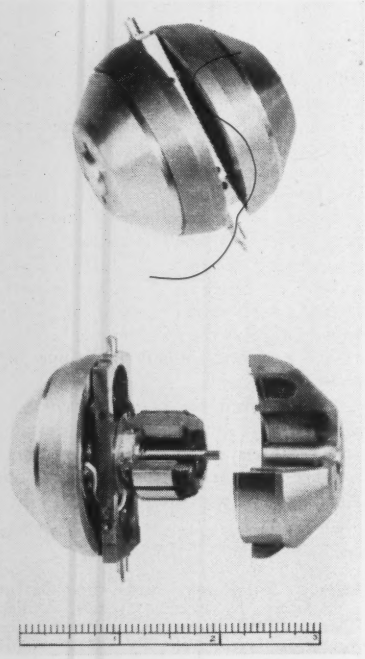
A PROBLEM which often faces production men is that of using new machines to their fullest advantage. Too frequently old standards are adapted to a newly purchased machine tool. Naturally, such practice results in a loss of the available productivity designed into the machine. It is therefore useful to have on hand specific cutting data which can be used as a guide for establishing proper cutting speeds and feeds on all new equipment.

This report covers the use of metal-cutting data obtained from chip studies, tool forces, and horsepower values for selecting an ideal cutting condition which combines tool life, heavy stock removal, and close accuracy for heavy-duty lathes.

Instruments and Regulators

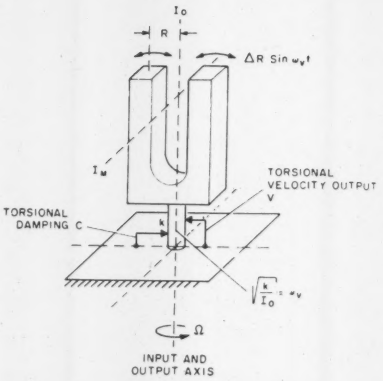
Symmetrical Aircraft Gyroscope Motor for Optimum Performance, by H. C. Wendt, General Electric Company, West Lynn, Mass. 1955 ASME Spring Meeting paper No. **55—S-26** (multilithographed; available to Feb. 3, 1956).

THE electrically-driven gyroscope is one of the major advances in the development of many simple and complex aircraft instruments and systems. However, the problems of bearings, mass shift, and windage are inherited from the air-driven rotors. To these are added magnetic effects, stator-winding mass shifts, effects of temperature gradients, and torques produced by the means to bring electrical power into the motor. Despite shortcomings the applications for the rotating mass are increasing manyfold. Demands for higher accuracies and greater ranges of operation are reflected in larger gyro motors of increased angular momentum on one hand, and reduced bearing friction by flotation methods on the other.



Symmetrical gyro motor *above* with cutaway view *below* showing internal construction. Essentially two motors have been mounted back to back with a common rotor shaft and bearings. The small flat mounting plate with integral bearing pivots here replaces the usual ring-type gimbal.

This paper describes a unique electric motor for aircraft gyroscopes which has a high angular momentum to weight ratio, operates over a wide temperature range, is small, withstands shock, vibration, environmental conditions, overvoltage, and excessive power under stalled conditions. This has been achieved by placing both the supporting member and stator structure within the rotor.



Basic vibratory-rate gyro system

Fundamentals of the Vibratory-Rate Gyro, by J. B. Chatterton, Sperry Gyroscope Company, Great Neck, L. I., N. Y. 1955 ASME Spring Meeting paper No. **55—S-25** (multilithographed; to be published in Trans. ASME; available to Feb. 3, 1956).

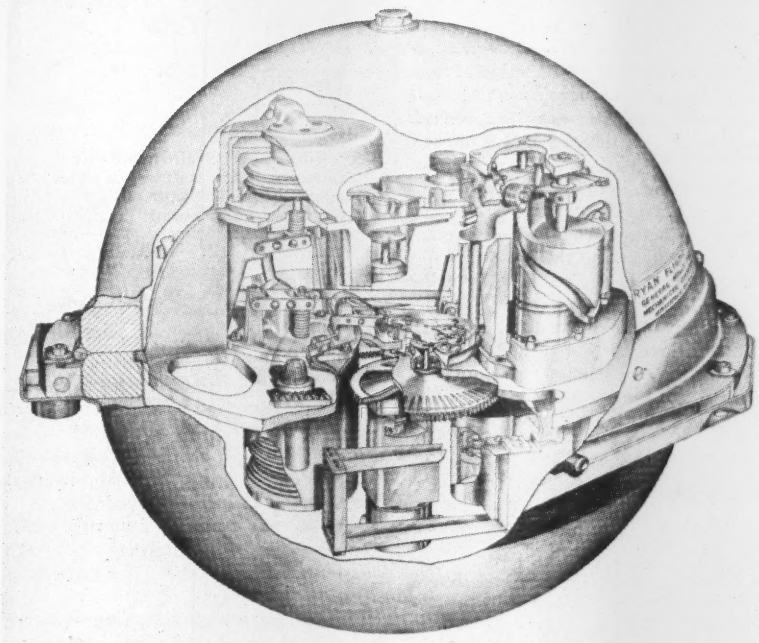
FOR many years the conventional-rate gyro has been the only practical primary instrument for the measurement of inertial angular velocity. The vibratory-rate gyro, which utilizes a vibrating rather than rotating mass, is a new instrument that also measures inertial angular velocity and appears to have several basic relative advantages. While vibratory-rate gyros are still in the experimental stage, it is believed that the basic configuration has been developed and is fundamental to a practical instrument of this type.

The important theoretical characteristics of the new vibratory type of rate gyro are discussed. Developed torque, output sensitivity, and frequency response are derived in a simple manner.

While no engineering details of a practical device are mentioned, the conclusion is reached that an instrument of this type is basically sound in principle.

The General Mills Ryan Flight Recorder, by J. J. Ryan, Mem. ASME, General Mills, Inc., and University of Minnesota, Minneapolis, Minn. 1955 ASME Spring Meeting paper No. **55—S-27** (multilithographed; available to Feb. 3, 1956).

THE Ryan flight recorder is an instrument for measuring and recording the basic conditions of flight in aircraft for long operating periods. It records the indicated air speed, static pressure, altitude, vertical acceleration, compass heading, and time by scribing on aluminum foil. From these records, information for determining a three-dimensional flight path is available. Measurement



Ryan flight recorder shown here is predominantly mechanical in operation and construction. It measures the indicated air speed, static pressure, altitude, vertical acceleration, compass heading, and time. An event marker indicates by a pip the time of any event desired for record by the pilot. The instrument is spherical in shape to maintain the greatest rigidity against impacts due to aircraft crash. Between an internal and external sphere is a 1-in-thickness of perlite insulation sufficient to prevent melting of the aluminum foil inside the recorder after ½-hr exposure to heat of a fuel fire.

on the vertical acceleration trace enables aircraft operators to evaluate the impact of exceedingly hard gusts or landing shocks, and ascertain the degree of maintenance inspection required. Abnormal atmospheric disturbances, aircraft operational variations, and instantaneous and long-time flight conditions are recorded.

The paper describes the flight-recording instrument which preserves an environment record for analysis under all conditions of aircraft flight, including crash. Need for such an instrument is discussed, and the construction of the device to fulfill this need is given. Reliability, accuracy, and survivability were stressed in the development. Specifications for recording altitude, air speed, vertical acceleration, compass heading, and time are outlined, and examples of operational tests are shown.

In application, the instrument is designed for use on all aircraft.

Operation, installation, maintenance, and record analysis are briefly described.

The conclusions refer to the instrument as a means for increasing the knowledge of flight conditions and the safety of aircraft. Its inclusion aboard all passenger aircraft is of particular interest to the CAA.

Applied Mechanics

Bending of Pretwisted Beams, by J. Zickel, General Electric Company, Schenectady, N. Y. 1955 ASME Spring Meeting paper No. **55—S-2** (in type; to be published in the *Journal of Applied Mechanics*).

THE general theory of pretwisted beams and columns is applied to the bending of an initially straight and uniformly pretwisted beam of doubly symmetric thin-walled section. Pretwisting brings planes of various bending stiffness into play with a resulting stiffness which in a sense averages the stiffness of the beam in its principal directions.

It is shown that compared with bending of an untwisted beam in its most flexible direction a thin strip can have its deflection in the plane of bending reduced 72 per cent by an initial twist of 0.83π. Simultaneously, however, lateral deflections of almost equal magnitude are induced. For pretwists above 2π, the lateral deflections become practically negligible and the deflections in the plane of bending are still reduced as much as 44 per cent. With increasing initial twist, however, the pretwisted beam becomes more flexible, and for an initial twist of 6.5π it is as flexible as the untwisted beam in its most flexible direction. Beams of equal flexibility in all directions simply become more flexible with initial twist, a fact which corresponds to the observations made by Den Hartog in some of his experiments.

Stress Distributions in Orthotropic Strips, by H. D. Conway, Assoc. Mem. ASME, Cornell University, Ithaca, N. Y. 1955 ASME Spring Meeting paper No. **55—S-1** (in type; to be published in the *Journal of Applied Mechanics*).

DISTRIBUTION of stress in orthotropic strips stretched by equal and opposite concentrated loads acting centrally and parallel to the longer sides is discussed.

Numerical results are given for oak, the grain being, respectively, perpendicular and parallel to the longer sides of the strip.

Vibrations of a Helicopter Rotor-Fuselage System Induced by the Main Rotor Blades in Flight, by M. Morduchow, S. W. Yuan, and H. Reissner, Mem. ASME, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1955 ASME Spring Meeting paper No. **55—S-7** (in type; to be published in the *Journal of Applied Mechanics*).

BASED on a simplified model of the hub-fuselage structure, a theoretical analysis is made of the response of the hub and fuselage of a helicopter in flight to harmonic forces transmitted by the rotor blades to the hub both in, and normal to, the plane of rotation. The assumed structure is in the form of a plane framework with masses concentrated at the joints.

Simple expressions are derived for the vibration amplitudes of the mass points as functions of the masses and natural frequencies of the hub and the fuselage. The pertinent nondimensional parameters are determined, and simple explicit conditions of resonance are derived.

Numerical examples are given to illustrate the results.

Matrix Analysis of Piping Flexibility, by J. E. Brock, Mem. ASME, U. S. Naval Postgraduate School, Monterey, Calif. 1955 ASME Spring Meeting paper No. **55—S-5** (in type; to be published in the *Journal of Applied Mechanics*).

SEVERAL correspondents have pointed out the inconvenience resulting from restricting the orientation symbols in an

earlier paper by the author, "A Matrix Method for Flexibility Analysis of Piping Systems," in which the letters appear in cyclic order x, y, z. Accordingly, Tables 7 and 8 of that reference are here extended, as Table 7(a) and 8(a), to include anticyclic symbols. It should be noted also that the formulas for k and β in Table 4 of the earlier paper are now obsolete.

Fuels Technology

Generation and Use of Sewage Sludge Gas in Municipal Sanitation, by R. A. Hoot, sanitary engineer, City of Philadelphia, Philadelphia, Pa. 1955 ASME Spring Meeting paper No. **55—S-8** (multilithographed; available to Feb. 3, 1956).

SEWAGE gas is the source of considerable potential energy. It has reliably been estimated that if all the energy contained in America's sewage could be captured, it would provide sufficient power to run a half-million-hp engine continuously. While this is a meager amount of energy compared with the power that could be obtained by harnessing the tides at Passamoquoddy or the power available from Norris Dam, still it is something worth considering.

In this paper the author attempts to explain descriptively how sewage is treated in the United States and how one of the main products of that treatment, sewage gas, is generated and used.

The paper takes up primary, secondary, and complete treatment, disposal of sludge, generation of sewage gas, starting a digester, explosion-proof equipment, and gas utilization.

Radiant Panels for Tin Reflow, Factors Leading to the Development of Radiant Gas-Fired Panels for Fusing Electrolytically Deposited Tin on Strip, by G. J. Campbell, Bethlehem Steel Company, Sparrows Point, Md. 1955 ASME Spring Meeting paper No. **55—S-22** (multilithographed; available to Feb. 3, 1956).

DEMAND for tin plate has increased phenomenally in recent years. From 1858 down to the present time, the predominant production demand has been for higher quality of cans to match the exacting requirements of the can industry, as they in turn enlarged the uses for packaging of various products in metal cans, which naturally led to continuous in-line manufacturing methods.

This paper deals with a process for continuously producing electrolytic tin plate and particularly the use of radiant gas-fired panels for fusing, melting, or reflowing the deposited matte tin coating into a homogeneous mass.

Following the first installation in 1936, the production of electrolytic tin plate has increased year after year, and since 1949, has exceeded the production of hot-dipped tin plate by margins which continue to grow as time goes on. Recent development of differential coating in which heavier coatings are deposited on one side of the sheet and comparatively light coatings on the other side will also materially increase the use of electrolytic plate and at the same time should reduce the cost of the product, by using less tin.

Radiant panels, almost identical with the panels used for tin fusion, are now being used for continuous annealing of tin plate and for continuous anneal and galvanizing of sheet steel.

Management

Co-Operative Training, by C. F. Roby, Mem. ASME. The Cincinnati Milling Machine Company, Cincinnati, Ohio. 1955 ASME Management Conference paper No. **55—MGT-3** (multilithographed; available to Jan. 1, 1956).

THE best way to accomplish more engineering at less cost is to have a joint educational program. Under this plan the colleges administer the theoretical training and industry contributes the practical training properly organized and so planned as to keep in step with the college curriculum. This is the co-operative plan.

With the fast-moving technological development of today, young engineers should not be trained on obsolete equipment but on the most up-to-date equipment possible. This phase of training can best be provided by industry.

The co-operative plan of education enables the engineering student to obtain a practical background in connection with his theoretical training at the university.

The plan is less costly to the student since he gets paid for the time that he is working in industry which enables him to defray a considerable amount of his expenses. It relieves the colleges of the original capital expense, necessary floor space, and maintenance of well-equipped machine-tool laboratories, as well as the expense of the instructors who are required to carry out the program. By conserving these facilities and using them for theoretical training only, the schools can provide more engineering at less cost. Practical training can be provided in industry at practically no extra cost as the students can be working on productive work and be self-supporting.

The co-operative plan provides the universities and industry with a real opportunity to present to the student a combined plan which will provide more engineering at less cost to the student, the university, and to industry.

Recruiting and Training Engineering Graduates for Industry, by R. E. Sprenkle, Mem. ASME, Bailey Meter Company, Cleveland, Ohio. 1955 ASME Management Conference paper No. **55—MGT-7** (multilithographed; available to Jan. 1, 1956).

THIS paper summarizes methods used by the author's company in selecting and training engineering graduates.

According to the paper, training programs for college graduates should provide the following:

1 A general orientation period in which company policies, organization, operational procedures, departmental or divisional functions, the company's outlook, career opportunities, and like matters are discussed by the top executives.

2 Assignment of all students on a rotative basis to all departments or divisions of the organization where, under close supervision, they will help build the equipment or products made in each department.

3 Sufficient time in the engineering, design, research and development, production, planning and/or other technical departments to learn at least the fundamentals of these activities in the organization, and just how they all dovetail together.

4 Classroom lectures and discussions covering basic technical fundamentals as applying to products or services, the products themselves, and their application to industry.

5 Opportunity for the student to select the kind of work in which he is most interested after the formal training program is completed.

6 After the formal training course has been finished and the actual job assignment has been made there should be additional training of the "on-the-job" type.

Progressive Management and the Engineer, by J. H. Elkus, Mem. ASME, Blaw-Knox Company, Pittsburgh, Pa. 1955 ASME Management Conference paper No. **55—MGT-2** (multilithographed; available to Jan. 1, 1956).

THE modern engineer can no longer isolate himself and work only as a creative engineer, unless he is involved solely in research, if both he and his company are to progress. He must recognize that

he is a member of a team and he must work in harmony with the other members of that team if conflict is to be avoided.

He must realize the importance of standardization, the limitations of plant equipment and personnel, the importance of labor relations, the necessity of production planning, material control, routing, and procurement; the importance of costs, quality control, and sales.

Today a complete knowledge of the principles of progressive management must be a part of his training and experiences in order that he may meet all the qualifications of a good engineer. He must understand the functions of all the other departments as well as his own and learn to appreciate the problems and skills of the men who work in them.

One practical way in which the young engineer can develop a working familiarity with all phases of industrial management is through an adequate orientation training program before beginning work as an engineer.

Many companies have found that by assigning and rotating the young engineer from department to department, plant to plant, and division to division, giving him a working familiarity with all functions of industrial management, he becomes a much more valuable member of the organization. Through such a program, his viewpoints become less narrow, his experience becomes broader, and his growth in management is likely to be more rapid. He is no longer just an engineer with technical training. He is an engineer equipped with a broad management viewpoint, able to take his place in a progressive management organization.

Streamlining Drafting Operations, by A. H. Rau, General Electric Company, Schenectady, N. Y. 1955 ASME Management Conference paper No. **55—MGT-6** (multilithographed; available to Jan. 1, 1956).

FULLER utilization of the higher abilities of engineers, designers, and draftsmen is a major challenge. To meet this challenge ways and means are needed to reduce the time and effort required to complete engineering projects successfully.

This paper discusses in some detail simplified drawings, standardization of engineering documentation, and control of drawing changes. Included is an appendage of short notations on other significant improvements in drafting methods and materials all designed to meet the needs of this streamlined age. Where they have been adopted, measurable increase in output and substantial improvement in over-all efficiency have been realized.

Get More Mileage From Your Engineers, by G. Kleis, Westinghouse Electric Corporation, East Pittsburgh, Pa. 1955 ASME Management Conference paper No. **55—MGT-8** (multilithographed; available to Jan. 1, 1956).

WE can expect more engineering output per engineer if we provide supporting personnel to perform the nontechnical and routine-technical aspects of his job. Such purification of the engineer's job stretches the engineer's effectiveness, makes for greater job satisfaction, and gets the "impure" work done more economically.

Engineers can be "saved" for the engineering job by employing and training nontechnical college graduates for "fringe-area" jobs.

Both technical and nontechnical college graduates can be most effectively and compatibly placed in their first job in industry through a good in-company training program. The proficiency level of all personnel, including technicians, can be increased substantially through an educational-assistance program. Add to these factors a good facilities program, including computers, and we will find tremendously improved "mileage" performance by professional engineers.

More Engineering at Less Cost Through the Use of Standard Parts, by C. Ainsworth, American Standards Association, New York, N. Y. 1955 ASME Management Conference paper No. **55—MGT-11** (multilithographed; available to Jan. 1, 1956).

TODAY, the increasing concern of progressive industry is finding new ways of increasing production at less cost per unit. Stiffer competition on all levels forces manufacturers to take advantage of every available dollar of purchasing power.

The answer to severe competitive pressure lies in better quality and greater productivity at less cost. This means more engineering in order to reduce production costs. Standardization is one of the important tools in reaching this goal. All true standardization work is co-operative in nature. A standard developed by only one individual or only one company, without consideration of the needs and experiences of others, is generally nothing but a piece of literature that no one reads, much less so, uses. It can never be a working tool.

The automotive industry, like all others who develop standards, began its standardization work in consultation with everybody who had an interest in automotive standards. Consumers, as well as suppliers, were called into the act. And standards were developed that finally benefit everybody.

The result was better engineering and lower costs for all concerned. All mass-producing industries benefited from the thinking and engineering practices of the automotive industry. Suppliers to the automotive industry obtained free engineering advice from a customer of great sales potential. Making use of this advice and experience, they were able to improve not only those products bought by the mass-producing customer, but their entire lines of products. By being able to engineer into their complete lines standard materials, parts, and practices, these suppliers reduced production costs, increased quality, and improved maintenance and serviceability.

Standards are creative tools that help to make better things at less cost and effort. True standards, like all creative matter, regenerate themselves.

Planning Tomorrow's Engineering Budget, by C. R. Sutherland, Mem. ASME, Reliance Electric & Engineering Company, Cleveland, Ohio. 1955 ASME Management Conference paper No. **55—MGT-10** (multilithographed; available to Jan. 1, 1956).

PREPARING tomorrow's engineering budget is to meet the demands of progress. Whether or not an individual industry survives the economic gales and swells depends on the preparation and care that went into the planning of the engineering budget.

The first item for review is the total cost of engineering, which normally includes the cost of personnel, development, research, operations, equipment, and miscellaneous. How much engineering? This is the first point that must be settled.

The breadth and depth of tomorrow's engineering department must be established by the job it will have to do. Competition, development, and new technological advances are important economic forces. Any industry that succeeds will have to establish an engineering force of necessary magnitude to accomplish this job. The demands of no two industries are alike.

Many plants have determined that past engineering budgets are no longer par on the industrial course. Engineers are looking for new ideas, principles, methods, and materials that will do the same job more economically. This requires a

greater engineering force, simply because the problems are getting tougher and more complex. Automation will increase the number of engineers still further. Management must recognize the inherent increase in engineering work load in the future and it must provide the budgets to provide advance products at lower costs.

It is engineering management's responsibility to lay the groundwork for the future. Before it can do so it must recognize the influencing factors which will determine the kind and amount of engineering required.

An adequate and proper engineering budget must be prepared. Determination of the proper amount for engineering expenditures related to sales dollar must be made. Planning of development and research programs must be established to meet competition and keep ahead of the field. Training of technical-engineering personnel is necessary in tomorrow's labor market. Better and proper office facilities will greatly aid the output of tomorrow's engineering department.

How Management Engineers Can Accomplish More, by V. M. Gelin, E. I. du Pont de Nemours & Company, Inc., Wilmington, Del. 1955 ASME Management Conference paper No. **55—MGT-9** (multilithographed; available to Jan. 1, 1956).

WHILE there is no evidence that management engineers are less effective than other engineers, they are more vulnerable because of the nature of their work, and understandably so because of the improvement medicine they are always prescribing for others. It has been the author's observation that management engineers are so preoccupied with making the work of others more effective that they have not given their own effectiveness as much attention as they are capable of giving.

In general, it appears that the problem of improving the effectiveness of management engineering work can be solved in three separate phases. All three are either entirely within the control of the engineers themselves or susceptible to their direct influence. These are:

1 The use of improved engineering techniques, which phase also encompasses internal organization and control of the work to be done.

2 Creation of a favorable management and supervisory climate.

3 Gaining acceptance by employees.

This paper discusses briefly these three phases of the problem.

Machine Design Conference

Production Considerations in Machine Design, by W. C. Allen, Westinghouse Electric Corporation, Pittsburgh, Pa. 1955 ASME Machine Design Conference paper No. **55—MD-4** (multilithographed; available to Feb. 3, 1956). Reported in MECHANICAL ENGINEERING, May, 1955, p. 465.

Designing for Production, Its Importance, Its Problems, and Suggested Solutions, by J. H. Conard, Niles-Bement-Pond Company, West Hartford, Conn. 1955 ASME Machine Design Conference paper No. **55—MD-5** (multilithographed; available to Feb. 3, 1956). Reported in MECHANICAL ENGINEERING, May, 1955, p. 465.

Production Considerations in Machine Design With Particular Reference to Such Products as Ball Bearings, by H. Michelsen, Mem. ASME, General Motors Corporation, Bristol, Conn. 1955 ASME Machine Design Conference paper No. **55—MD-6** (multilithographed; available to Feb. 3, 1956). Reported in MECHANICAL ENGINEERING, May, 1955, p. 465.

Mechanizing Machine Tools for Diversified Production, by B. D. Smith, Mem. ASME, International Harvester Company, Chicago, Ill. 1955 ASME Machine Design Conference paper No. **55—MD-7** (multilithographed; available to Feb. 3, 1956). Reported in MECHANICAL ENGINEERING, May, 1955, p. 465, 468.

Production Considerations in Machine Design, by E. P. Bullard III, Pratt & Whitney Aircraft Corporation, East Hartford, Conn. 1955 ASME Machine Design Conference paper No. **55—MD-2** (multilithographed; available to Feb. 3, 1956). Reported in MECHANICAL ENGINEERING, May, 1955, p. 468.

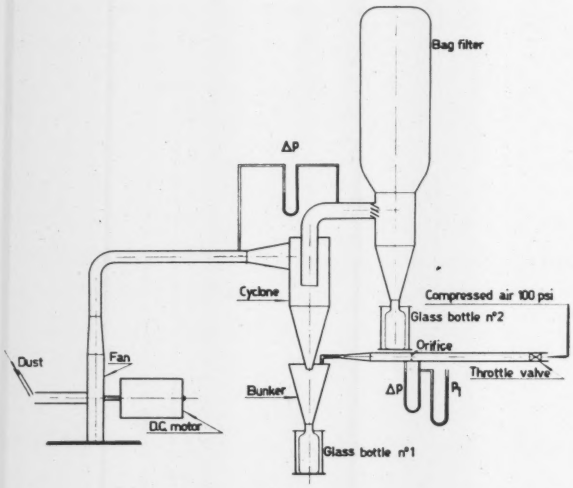
Production Considerations in Machine Design, by W. C. Cadwell, Caterpillar Tractor Company, Peoria, Ill. 1955 ASME Machine Design Conference paper No. **55—MD-1** (multilithographed; available to Feb. 3, 1956). Reported in MECHANICAL ENGINEERING, May, 1955, p. 468.

Production Considerations in the Design of Heavy Machinery, by C. A. Jurgensen, Mem. ASME, De Laval Steam Turbine Company, Trenton, N. J. 1955 ASME Machine Design Conference paper No. **55—MD-3** (multilithographed; available to Feb. 3, 1956). Reported in MECHANICAL ENGINEERING, May, 1955, pp. 468 and 469.

Air Pollution Control

Influence of the Size of the Dust-Collector Outlet of a Cyclone on Its Efficiency, by H. J. van Ebbenhorst Tengbergen, Netherlands State Mines, Treebeck, The Netherlands. 1955 ASME International Air Pollution Congress paper No. **55—APC-8** (multilithographed; available to Jan. 1, 1956).

SINCE it often happens that the separation of dust from a gas stream in a cyclone is hindered owing to insufficient sealing of the dust bunker, it appeared desirable to study this problem experimentally.



Equipment for cyclone tests. The setup shown was especially arranged for measuring the collecting efficiency of cyclones. In bottle 1 the dust separated in the cyclone is collected, while the dust not retained by the cyclone and collected from the filter bag (after the fan has been stopped) is put into bottle 2. It was assumed that all the dust which had escaped from the cyclone was collected in the filter bag.

The conditions outlined in the paper apply both to a single cyclone placed in a gas-transport system and to several such cyclones arranged in parallel, including multicyclones. For the sake of simplicity all the experiments were carried out with one cyclone, although not always of the same type. The dust was introduced into an air stream which by means of a fan was forced through the cyclone and next returned into the atmosphere through a filter bag.

Biological Systems for the Identification and Distribution of Air Pollutants, by J. T. Middleton, University of California, Riverside, Calif. 1955 ASME International Air Pollution Congress paper No. **55—APC-11** (multilithographed; available to Jan. 1, 1956).

INSTRUMENTATION may provide specific delimitation of pollution by sulphur dioxide. The same is to be hoped for with the measurement of atmospheric fluorides by the Stanford Research Institute instrument. The presence and distribution of hydrogen sulphide, other sulphurous materials expressed as total sulphur, and oxidants measured by release of iodine from potassium iodide cannot be done by instrumentation alone. It becomes necessary, therefore, in determining, measuring, and accurately evaluating the pollutants in urbanized areas, to include the response of a biological system.

This paper discusses monitoring and recording instruments, ozone damage, relation between plant damage and oxidant level, and growth suppressors.

Measurement of Average Particle Size in Aerosols by Light Scattering, by D. Sinclair, Johns-Manville Research Center, Manville, N. J. 1955 ASME International Air Pollution Congress paper No. **54—APC-10** (multilithographed; available to Jan. 1, 1956).

MEASUREMENTS on uniform particle-size aerosols and the Mie theory of light scattering show that most light-scattering functions, such as scattering cross section, depolarization, and ratio of forward-to-back-scattering are multiply valued over even a small range of particle size. Calculations described in this paper show that the ratio of small-angle forward scattering (2 to 10 deg) to right-angle scattering is singly valued over a large and useful range of particle size. This ratio increases continuously (though not uniformly) from 2 in the Rayleigh region to about 500 at 6 microns diam. Measurements of this ratio in a nonuniform particle-size aerosol could be used to measure an approximate average particle size or to determine whether a change in scattered light intensity was caused by a change in the particle size or a change in concentration. The method would tell nothing about the distribution of particle size, but it would tell that the predominant size fell within a certain range. The information could be recorded continously as is done in the Sinclair-Phoenix aerosol photometer. Two light-scattering chambers and two phototubes would be required to simultaneously record the forward and 90-deg scattering, either of which could be used as a measure of concentration. Preliminary experiments have shown that the requisite small-angle scattering can be obtained.

ASME Transactions for May, 1955

THE May, 1955, issue of the Transactions of the ASME (available at $1 per copy to ASME members; $1.50 to nonmembers) contains the following:

Technical Papers

Some Statistical Methods for Evaluation of Experimental Results, by E. W. Pike. (53—A-164)

Design of Power-Plant Tests to Insure Reliability of Results, by W. A. Wilson. (53—A-156)

Measurement Errors—Classification and Interpretation, by J. C. Boonshaft. (53—A-219)

The Latexing and Hot-Stretching of Tire-Cord Fabrics With Special Emphasis on Nylon, by C. A. Litzler.

Action of Boiler Water on Steel—Attack by Bonded Oxygen, by C. E. Kaufman, W. H. Trautman, and W. R. Schnarrenberger. (53—A-241)

Corrosion of Steel in Boilers—Attack by Dissolved Oxygen, by H. A. Grabowski. (53—A-226)

Experimental Boiler Studies of the Breakdown of Amines, by C. Jacklin. (53—A-240)

Compressor Surge and Stall Propagation, by H. W. Emmons, C. E. Pearson, and H. P. Grant. (53—A-65)

Pin-Fin Heat-Exchanger Surfaces, by W. M. Kays. (53—A-211)

Grinding Capacities of Cane-Sugar Mills, by Jose M. Cabrera. (54—MEX-14)

Conveying Equipment in Cane-Sugar Mills, by C. Conrad Rinelli. (54—MEX-2)

Contribution to the Knowledge of Pressure Measurements During Metal Deformation, by J. Frisch. (54—MEX-19)

A New Approach to Metal-Forming Problems, by E. G. Thomsen. (54—MEX-16)

The San Bartolo Vertical Impulse Turbine, by Javier Fuentes, Salvador Almanza, and W. J. Rheingans. (54—MEX-9)

Mechanism of Cavitation Inception and the Related Scale-Effects Problem, by R. W. Kermeen, J. T. McGraw, and B. R. Parkin. (54—MEX-1)

Refrigerating-Plant Performance Characteristics by Electrical-Analog Analysis, by Carl F. Kayan. (54—MEX-11)

Bagasse-Burning in the Mexican Sugar Industry, by Otto de Lorenzi. (54—MEX-4)

British Naval Gas Turbines, by G. F. A. Trewby.

The Dynamics of Filled Temperature-Measuring Systems, by Otto Muller-Girard. (54—SA-29)

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NOTE: No digests are made of ASME papers published in full or condensed form in other sections of MECHANICAL ENGINEERING.

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55—S-7 Vibrations of a Helicopter Rotor-Fuselage System Induced by the Main Rotor Blades in Flight, by M. MORDUCHOW, S. W. YUAN, and H. REISSNER

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Process Industries

55—S-38 Is Chemistry in the Power Plant an Exact Science? by F. U. NEAT

Reviews of Books

And Notes on Books Received in Engineering Societies Library

Failure of Structural Units

TECHNICAL REPORT, NEW SERIES, vol. 2, September, 1954, British Engine Boiler & Electrical Insurance Co., Ltd., Manchester, England. Paper, 9½ × 7 in., 21 figs., 256 pp., 12s., 6d.

Reviewed by John M. Lessells[1]

FURTHER information on the failure of structural units is given in volume 2 of the New Series of Technical Reports issued by the British Engine Boiler & Electrical Insurance Co., Ltd. Such kind of knowledge, as mentioned in the review of volume 1 published in the JOURNAL OF APPLIED MECHANICS for September, 1953, page 451, is of extreme importance to all engineers concerned with the design and operation of structural parts.

The present volume devotes the first section to a historical review of a century's progress in the organized inspection of engineering plants. It is interesting to learn that in 1854 boiler explosions were generally regarded as fortuitous, and it was not until the efforts of such engineering giants as Fairbairn, Whitworth, Longridge, and others that a more rational approach was made to the design and operation of pressure vessels. Some interesting remarks are made on the contribution of the competent inspection provided by such insurance companies as the British Engine Boiler & Electrical Insurance Company in assisting to avert such failures by the dissemination of technical knowledge regarding particular failures. All engineers will agree with the statement in the report regarding the future possibilities which lie open before the engineer: "There is no doubt that mankind stands on the threshold of an era that is likely to surpass in technological development the ones that preceded it. It may be that in a hundred years the basic prime movers of today may join the beam engine and the Haystack boiler as museum curiosities."

The next section is devoted to a discussion of failure of a variety of units such as steam boilers, pipe flanges, turbine bearings, and the like. Interesting descriptions are given of several crankshaft failures. These indicate the influence of bad welding technique on such failures. Other cases are cited which show the possible influence of chromium plating in reducing the fatigue strength unless proper attention is given to the chromium-plating technique. All of these are problems of current engineering significance.

Not the least of the interesting features of this and the previous report are the excellent macrographs and micrographs which have been used with competent metallurgical knowledge as an aid to the engineer in uncovering the causes of failure.

The latter part of the report is devoted to a review by the Company's research engineer, G. A. Cottell, of the knowledge of fatigue phenomena. This includes a discussion of crack formation and growth on which more knowledge is still required by the engineer. An interesting bibliography draws attention to the pertinent literature of the subject.

[1] President, Lessells and Associates, Inc., Boston, Mass.; Associate Professor of Mechanical Engineering, Emeritus, Massachusetts Institute of Technology, Cambridge, Mass. Hon. Mem. ASME.

Books Received in Library...

ASTM STANDARDS ON PETROLEUM PRODUCTS AND LUBRICANTS. American Society for Testing Materials, Philadelphia, Pa., 1954. 956 p., 9 × 6 in., paper. $6 (members $4.50). A compilation of specifications, test methods, and definitions covering crude petroleum, motor and aviation fuels, lubricating oils, turbine oils, bituminous materials, and other broad classifications. Contents are arranged in numeric sequence by ASTM designations and a subject index is provided.

ADVANCED MATHEMATICS FOR ENGINEERS. By H. W. Reddick and F. H. Miller. Third edition prepared by F. H. Miller. John Wiley & Sons, Inc., New York, N. Y., 1955. 548 p., 8¼ × 5⅝ in., bound. $6.50. This book is intended for the reader with a thorough training in engineering mathematics through calculus. Beginning with ordinary differential equations, the book takes up, in order, hyperbolic functions; elliptic integrals; infinite series; Fourier series; gamma, Bessel, and Legendre functions; partial derivatives and partial differential equations; vector analysis; probability; functions of a complex variable; and operational calculus. Problems relating to civil, electrical, chemical, and mechanical engineering are given with each principal topic.

APPLIED X-RAYS. By George L. Clark. McGraw-Hill Book Company, Inc., New York, N.Y., fourth edition, 1955. 843 p., 9¼ × 6¼ in., bound. $12.50. A comprehensive study of x rays as a practical research tool in industry, thoroughly revised to include the many advances since publication of the previous edition in 1940. The material is presented in two sections, the first, covering general physics and applications, the second, analysis of the ultimate structures of materials. New developments in x-ray optics and microscopy are discussed, and special attention is given to chemical analysis by fluorescence.

AUTOMATIC FEEDBACK CONTROL SYSTEM SYNTHESIS. By John G. Truxal. McGraw-Hill Book Company, Inc., New York, N.Y., 1955. 675 p., 9¼ × 6¼ in., bound. $12.50. Intended as a text for a graduate course in servomechanisms and as a reference book for engineers in industry, this book reviews the elements of Laplace transform and complex function theory and treats in detail basic concepts of feedback theory; design in terms of the Laplace transforms; statistical design fundamentals and applications; and the analysis of nonlinear feedback systems. Although the main emphasis is on theory, some practical examples are used to illustrate the discussion.

BETRIEB UND ANWENDUNG VON LEISTUNGS- UND REGELTRANSFORMATOREN. By Fritz André. Springer-Verlag, Berlin, Germany, 1954. 319 p., 9¼ × 6¼ in., bound. 33 DM. A treatise on the operation and application of power and regulating transformers, designed to provide engineers with the necessary information for the proper selection and operation of modern equipment. Detailed sketches and graphs accompany the descriptive treatment of the various types.

MASS BALANCING OF AIRCRAFT CONTROL SURFACES. (Royal Aeronautical Society, Aeronautical Monographs, volume 4.) By H. Templeton. Chapman & Hall, Ltd., London, England, 1954. 241 p., 8¾ in., bound, 35s. The three parts of this study are devoted to basic principles of mass balancing, applications to the prevention of flutter of aircraft control surfaces, and a forecast of possible future developments. Most of the factual material of interest to designers and research workers is presented in the second

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part which covers design criteria, procedures for mass balancing, various mass-balancing systems, and an account of British investigations on the problem of control surface flutter. A bibliography is included.

PROCEEDINGS OF THE FIRST NATIONAL TURBINE POWERED AIR TRANSPORTATION MEETING. Institute of the Aeronautical Sciences, New York, N.Y., 1954. 218 p., 11 × 8½ in., paper. $6 (members $3.50). The fifteen papers included deal with a variety of problems involved in developing a transportation system using turbine-powered air transport. Several of the papers consider the design and performance of different types of transports; others consider operational characteristics of propellors for turboprop engines, water bases for jet transports, selection of fuels, and related topics.

PRODUCTION TOOLING EQUIPMENT. By S. A. J. Parsons. Cleaver-Hume Press, Ltd., London, England, 1954. 324 p., 8¾ × 5½ in., bound. 25s. Coverage includes jigs and fixtures, discussed in relation to the components with which they are to be used; cutting tools, including microdrills, high-rake milling cutters, and sliding-head-type automatics; gage design; and various economic aspects of tooling up. Essentially practical, with emphasis on modern techniques, the book is intended for engineers, students, and those preparing for professional examinations. Typical problems drawn from British examinations are included.

SCHNITT-, STANZ- UND ZIEHWERKZEUGE. By Gerhard Oehler. Springer-Verlag, Berlin, Germany, second edition, 1954. 480 p., 9¼ × 6¼ in., bound. 37.50 DM. Intended primarily for tool and die makers, this treatise on cutting, blanking, and drawing dies is also suitable for design engineers. The new edition covers recent developments such as bulging, reverse redrawing, stretching, multiple-stage pressing, etc. Advantages and disadvantages of various die types and operations are discussed, and special attention is paid to selection of tool steels for die production.

STAUANLAGEN UND WASSERKRAFTWERKE. Part 3: Wasserkraftwerke. By Heinrich Press, Wilhelm Ernst & Sohn, Berlin, Germany, 1954. 340 p., 9½ × 6¾ in., paper. 35 DM. The design, construction, and operation of hydroelectric power plants are dealt with in this third volume of a series on dams and power plants. It covers structural details, turbines, and auxiliary installations—both high and low head, and methods of calculation of water hammer, head losses, etc. Underground and submerged plants are included.

SYMPOSIUM ON EFFECT OF CYCLIC HEATING AND STRESSING ON METALS AT ELEVATED TEMPERATURES. (Special Technical Publication No. 165.) American Society for Testing Materials, Philadelphia, Pa., 1954. 175 p., 9 × 6 in., paper. $3. Situations involving relatively slow changes in stress or temperature, or both, are covered in the eight papers presented. Specific topics dealt with include thermal-stress fatigue in austenitic steels at elevated temperatures; temperature-cycling effects on rupture strength of high-temperature alloys; effects of temperature and load changes on creep rupture of steels; and similar studies of the behavior of Inconel, aircraft sheet alloys, Fe-Cr-Ni alloys, and other materials.

TITANIUM IN INDUSTRY. By Stanley Abkowitz, John J. Burke, and Ralph H. Hiltz, Jr. D. Van Nostrand Company, Inc., New York, N.Y., 1955. 224 p., 9¼ in. × 6 in., bound. $5. A treatise on the elementary facts and principles involved in the use of titanium, written for process engineers and research metallurgists. Methods of production, properties, and alloying and heat-treatment are discussed, and separate chapters are devoted to hot and cold shaping, casting and powder metallurgy, joining, and machining and grinding. Analytical and metallographic techniques are also described and military and industrial applications are briefly noted. Companies that are the main producers of titanium are listed in the opening chapter.

VIBRATION PROBLEMS IN ENGINEERING. By S. Timoshenko. D. Van Nostrand Company, Inc., New York, N. Y., third edition, 1955. 468 p., 9¼ × 6 in., bound. $8.75. This standard work on fundamentals and applications of vibration theory has been thoroughly revised to incorporate important new developments. The first chapter, on systems having one degree of freedom, has been thoroughly recast; the chapter on nonlinear vibrations has been expanded to include new methods of treatment; and the chapter covering elastic bodies has been completely revised. In the latter, new topics, such as combined bending and torsional vibrations of beams, are discussed. The appendix, dealing with measuring instruments, has been omitted from this edition.

WAVE DIAGRAMS FOR NONSTEADY FLOW IN DUCTS. By George Rudinger. D. Van Nostrand Company, Inc., New York, N. Y., 1955. 278 p., 9¼ × 6¼ in., bound. $6. Fundamentals and step-by-step procedures for the construction of wave diagrams are presented and applied to general flow problems, and to problems involving boundaries and discontinuities and the interaction of discontinuities. Actual techniques of wave-diagram construction are described, with completely worked-out examples given as illustrations. This is intended both as a textbook and reference manual. A familiarity with problems of steady, compressible flow in ducts is assumed.

ZAHNRÄDER. Volume I. Stirn- und Kegelräder mit geraden Zähnen. By W. Lindner. Fourth, entirely revised edition, 1954, Springer-Verlag, Berlin, Germany, 133 p., 10¾ × 7½ in., paper. 18 DM. This first volume of a series on gear technology deals with spur and bevel gears having straight teeth. Part 1 covers kinematic and analytical fundamentals of tooth construction and the general concept of the tooth system. Part 2 covers applications including noncircular, planetary, and other special gear types. It also deals briefly with gear manufacture and the design of gear systems.

ASME BOILER AND PRESSURE VESSEL CODE . . .

Proposed Revisions and Addenda to Boiler and Pressure Vessel Code . . .

AS NEED arises, the Boiler and Pressure Vessel Committee entertains suggestions for revising its Code. Revisions approved by the Committee are published here as proposed addenda to the Code to invite criticism. If and as finally approved by the ASME Board on Codes and Standards, and formally adopted by the Council, they are printed in the annual addenda supplements to the Code. Triennially the addenda are incorporated into a new edition of the Code.

In the following the paragraph numbers indicate where the proposed revisions would apply in the various sections of the Code.

Comments should be addressed to the Secretary of the Boiler and Pressure Vessel Committee, ASME, 29 West 39th Street, New York 18, N. Y.

TABLE P-7 Under SA-268, Grades TP-405, TP-410, and TP-430, Welded Alloy Steel only, delete the stress values above 700 F.

Power Boilers, 1952

TABLE P-6 Add the accompanying stress values.

STRESS VALUES TO BE ADDED TO TABLE P-6

For Metal Temperatures Not Exceeding Deg F

Serial and Spec No.	Grade, Type or Name	Condition	Notes	Spec Min Tensile	Subzero to 150
COPPER ALLOYS					
Pipe or Tube					
SB-111 Seamless tubes	Copper-nickel 70–30	annealed	(2)	55000	13300
SB-111 Seamless tubes	Copper-nickel 80–20	annealed	(2)	50000	12000
SB-111 Seamless tubes	Copper-nickel 90–10	annealed	(2)	40000	10000

250	300	350	400*	450	500	550	600	700	800
12700	12300	12000	11700	11300	11000	10500	10000	9000	...
11300	11000	10700	10300	10000	9500	9000	8500	7500	...
9500	9300	9000	8700	8300	7500	6700	6000	...	...

TABLE P-7 For SA-376, Seamless Austenitic Steel Pipe for High-Temperature Central Station Service, add the accompanying stress values.

Material Specifications, 1952

The revised specifications published in the March, 1955, MECHANICAL ENGINEERING will assume the existing allowable stress values as contained in Section I, Power Boilers and Section VIII, Unfired Pressure Vessels.

The Boiler and Pressure Vessel Committee has approved adding to Section II the following specification:

SB-234-54T, Specification for Aluminum-Alloy Drawn Seamless Tubes for Condensers and Heat Exchangers, with the exception of alloy GS11C.

Unfired Pressure Vessels, 1952

PAR. UCL-23(c) Revise to read:

(c) When the joints are completed by depositing corrosion-resisting weld metal over the weld in the base plate to restore the cladding, the design calculations may be based on a thickness equal to the nominal thickness of the base plate plus S_c/S_b times the nominal thickness of the cladding after any allowance provided for corrosion has been deducted.

Where S_c = maximum allowable stress value for the cladding at the design temperature, psi

S_b = maximum allowable stress value for the base plate at the design temperature, psi

Where S_c is greater than S_b, the multiplier S_c/S_b shall be taken equal to unity. Vessels in which the cladding is included in the computation of wall thickness shall not be constructed under the provisions of Par. UW-52(b).

PAR. UCL-36(b) Revise to read:

(b) Joints welded with austenitic chromium-nickel steel electrodes other than those in material having either type 405 or type 410 alloy lining with carbon not to exceed 0.08 per cent shall be given a radiographic spot examination. The examination shall be made in accordance with the requirements for spot-radiography in Par. UW-52. At least one spot-examination shall include a portion of the lining weld that contacts weld metal in the base plate. This examination of the austenitic weld deposits is not required of such joints welded with austenitic chromium-nickel steel electrodes consisting either of type 405 or of 410 with 0.08 per cent maximum carbon.

TABLE UHA-23 For SA-376, Seamless Austenitic Steel Pipe for High-Temperature Central Station Service, add the accompanying stress values.

TABLE UNF-23 Under Pipes and Tubes add SB-234, Grade GS11A, with the same stress values as now included in this table for SB-274, Grade GS11A of T6 temper.

Erratum to 1954 Addenda to Unfired Pressure Vessels.—On page 47, Table 12—600-Pound Class B Pressure-Temperature Ratings, the rating for Type 316 at 100 F should read "1200" instead of "1900."

MATERIALS AND STRESS VALUES TO BE ADDED TO TABLE P-7

For Metal Temperatures Not Exceeding Deg F

Spec No.	Grade	Nom Comp	Spec Min Tensile	Notes	—20 to 100	200	300	400	—20 to 400
PIPES & TUBES									
Seamless Alloy Steel									
SA-376	TP304	18 Cr-8 Ni	75000	(7)	18750	17000	16000	15450	...
SA-376	TP304	18 Cr-8 Ni	75000	...	18750	16650	15000	13650	...
SA-376	TP321	18 Cr-8 Ni-Ti	75000	...	18750	18750	17000	15800	...
SA-376	TP347	18 Cr-8 Ni-Cb	75000	...	18750	18750	17000	15800	...
SA-376	TP316	16 Cr-13 Ni-3 Mo	75000	...	18750	18750	17900	17500	...

For Metal Temperatures Not Exceeding Deg F

500	600	650	700	750	800	850	900	950	1000	1050	1100	1150
15100	14900	14850	14800	14700	14550	14300	14000	13400	12500	10000	7500	5750
12500	11600	11200	10800	10400	10000	9700	9400	9100	8800	8500	7500	5750
15200	14900	14850	14800	14700	14550	14300	14100	13850	13500	13100	10300	7600
15200	14900	14850	14800	14700	14550	14300	14100	13850	13500	13100	10300	7600
17200	17100	17050	17000	16900	16750	16500	16000	15100	14000	12200	10400	8500

For Metal Temperatures Not Exceeding Deg F

1200	1250	1300	1350	1400	1450	1500	PIPES & TUBES Seamless Alloy Steel	
4500	3250	2450	1800	1400	1000	750	SA-376	TP304
4500	3250	2450	1800	1400	1000	750	SA-376	TP304
5000	3300	2200	1500	1200	900	750	SA-376	TP321
5000	3300	2200	1500	1200	900	750	SA-376	TP347
6800	5300	4000	2700	2000	1500	1000	SA-376	TP316

MATERIALS AND STRESS VALUES TO BE ADDED TO TABLE UHA-23

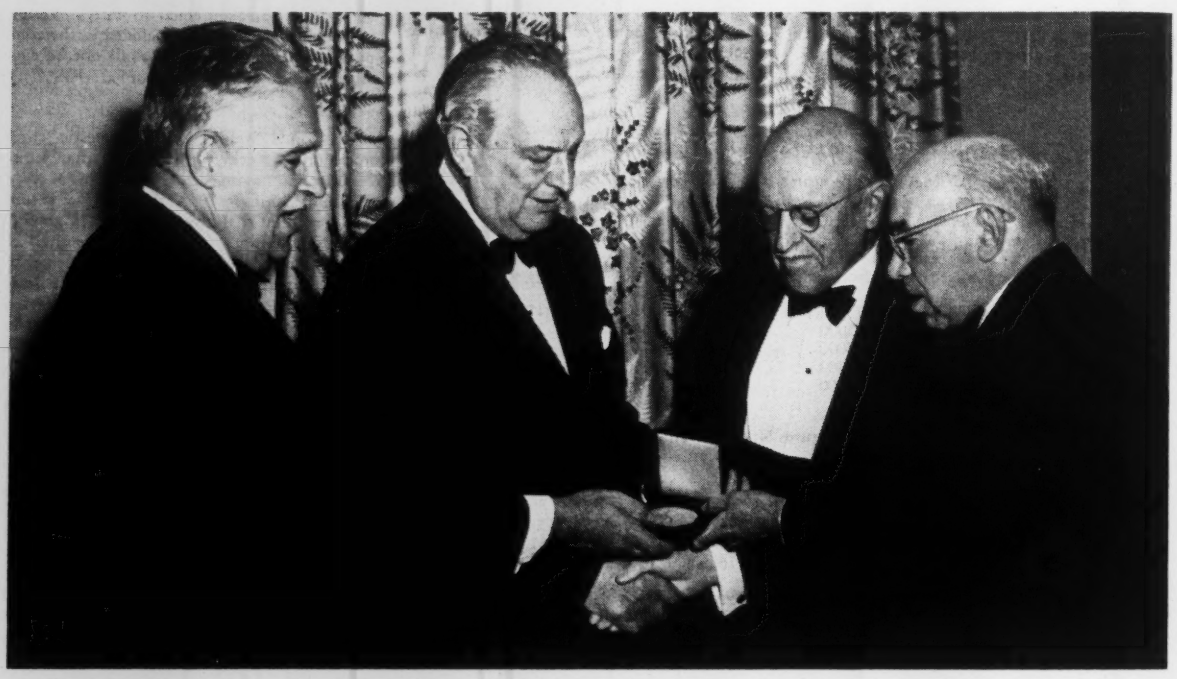
Mat'l and Spec No.	Grade	Type	Nom Comp	Spec Min Tensile	Notes	—20 to 100	200	300	400	500	600	650	700	750
						For Metal Temperatures Not Exceeding Deg F								
PIPES & TUBES														
Seamless														
SA-376	TP304	...	18 Cr-8 Ni	75000	(1)	18750	17000	16000	15450	15100	14900	14850	14800	14700
SA-376	TP304	...	18 Cr-8 Ni	75000	...	18750	16650	15000	13650	12500	11600	11200	10800	10400
SA-376	TP321	...	18 Cr-10 Ni-Ti	75000	...	18750	18750	17000	15800	15200	14900	14850	14800	14700
SA-376	TP347	...	18 Cr-10 Ni-Cb	75000	...	18750	18750	17000	15800	15200	14900	14850	14800	14700
SA-376	TP316	...	16 Cr-13 Ni-3 Mo	75000	...	18750	18750	17900	17500	17200	17100	17050	17000	16900

For Metal Temperatures Not Exceeding Deg F

800	850	900	950	1000	1050	1100	1150	1200	1250	1300	1350	1400	1450	1500	Mat'l and Spec No.	Grade
															PIPES & TUBES	
															Seamless	
14550	14300	14000	13400	12500	10000	7500	5750	4500	3250	2450	1800	1400	1000	750	SA-376	TP304
10000	9700	9400	9100	8800	8500	7500	5750	4500	3250	2450	1800	1400	1000	750	SA-376	TP304
14550	14300	14100	13850	13500	13100	12500	8000	5000	3600	2700	2000	1550	1200	1000	SA-376	TP321
14550	14300	14100	13850	13500	13100	12500	8000	5000	3600	2700	2000	1550	1200	1000	SA-376	TP347
16750	16500	16000	15100	14000	12200	10400	8500	6800	5300	4000	3000	2350	1850	1500	SA-376	TP316

ASME NEWS

With Notes on the Engineering Profession



Lieut. Gen. Leslie R. Groves, *left,* called for dispersal of industry and population centers for defense against atomic attack. He spoke at the 1955 ASME Diamond Jubilee Spring Meeting. Second from *left* is Granville M. Read, chief engineer of E. I. du Pont de Nemours & Company, Inc., who received the Society's highest award, the 1955 ASME Medal. Second from *right* is U. S. Senator Ralph E. Flanders (R., Vt.), past-president of ASME, who acted as toastmaster at the banquet. At *right* is ASME President David W. R. Morgan and vice-president of Westinghouse Electric Corporation.

Engineer and World of Government Theme of ASME Diamond Jubilee Spring Meeting

Technical sessions, inspection trips, and social events round out six-day program

FEATURING two-panel sessions on the general theme "The Engineer's Responsibilities in the World of Government," the ASME Diamond Jubilee Spring Meeting attracted more than 1000 ASME members, wives, and guests from all parts of the United States to Baltimore, Md., during the week of April 17, 1955. The meeting marked a double anniversary: The 75th birthday of ASME and the 25th for the American Rocket Society, an ASME affiliate.

Two hotels, the Lord Baltimore and the Southern, were necessary to accommodate ASME's 27 sessions at which 69 technical papers were presented. In addition, the ARS program included three sessions and ten technical papers.

Six inspection trips to industrial plants and government installations in the Baltimore area added to the week's activities.

Major social function of the meeting was the banquet on Tuesday evening at which Lieut. Gen. Leslie R. Groves, of atomic-bomb fame, delivered the principal address. Other principal functions included the President's Luncheon on Monday, a Management Luncheon on Tuesday, an ARS Luncheon on Wednesday, and a dinner on Wednesday evening given by the Glenn L. Martin Company of Baltimore.

The visiting engineers and their wives also took time out to relax. The program included a reception on Sunday evening, a tea dance on Monday sponsored by the Woman's Auxiliary to the ASME Baltimore Section; an oyster roast on Thursday evening at the Alcazar Restaurant; and a night baseball game between the New York Yankees and the Baltimore Orioles. In addition, the Ladies' Program included a luncheon and card party on Wednesday at the Baltimore Country Club.

Engineers' Responsibilities to Government

In the Military Defense of the Nation. In the first of two 75th Anniversary Panels, ASME Members and guests heard Frank D. Newbury, assistant secretary of defense for applications engineering, state flatly that the United States does not have the technical manpower to keep prepared for "both the old and new kinds of war."

He said that we must promote a policy of concentration of our limited national technical and industrial resources on a smaller variety of weapons and equipment.

If we ever lose the armament race to the USSR, it will be because the USSR has of necessity practiced a policy of selection of its objectives and concentration on heavy industry as against consumer goods, and concentration on a relatively few sizes and types of weapons and weapons in its military, he added.

Mr. Newbury defended recent decisions by the Defense Department to cutback appropriations in certain areas by arguing that "appropriations, alone, do not produce new aircraft, or guided missiles, or electronic gear."

"Reductions in appropriations that Secretary Wilson has recommended, and to some extent carried out, for new aircraft, for example, have been followed by excited charges that our military strength was automatically and inevitably reduced," he said. "The most serious limitation on progress in our over-all defensive position, especially in the development field, is the scarcity of qualified scientists and engineers to man them—not funds."

Mr. Newbury listed four important objectives of his office, which was established upon recommendation of the Rockefeller Committee: (1) Concentration on a smaller number of major developments, in order to conserve limited national resources of qualified engineering manpower and industrial organizations; (2) consolidation of similar engineering experience within different military departments and "gradual but accelerated" consolidation of development facilities of the departments; (3) assignment to separate services of responsibility for development of specific types of equipment to be used by more than one service; and (4) a policy of awarding initial production contracts to the contractor who develops a new device, and not necessarily to the lowest bidder.

In the Industrial Defense of the Nation. America's engineers were told that they hold prime responsibility for the industrial defense of the nation by R. E. Gillmor, retired vice-president of the Sperry Corporation, New York, N. Y.

He said that when war comes our enemies will probably have superiority in numbers of trained troops, in many of the primary weapons, and in some of the natural resources.

Our greatest opportunity for attaining military superiority, he added, lies in "the free and imaginative application of technical knowledge, experience, and skill."

The imperialistic oligarchies in Russia and China have, by a form of slavery, been able to pursue a policy of guns before butter, he said. As a free, nonimperialistic people we and our allies must pursue a guns-and-butter policy. Therefore, so long as the war remains cold, we cannot expand our defense industries much beyond their present level. Since the last war our military services have wisely distributed development and production contracts to many industries not normally engaged in military work, he pointed out.

The engineers in the industries that specialize in development and production for the military services will be of great importance in converting other industries to war production, he added.

Mr. Gillmor praised the work of American engineers who have served in foreign countries under the auspices of the Economic Co-Operation Administration and its successor, the Mutual Security Administration. They have contributed greatly, he said, to the combined industrial strength of the free world.

In Government Operations. Technical problems confront all forms of government—federal, state, and municipal, Harold V. Coes, past-president and Hon. Mem. ASME, told the audience. Yet, he said, while engineers are responsible citizens, there are many school boards, for example, without an engineer on them. These boards and other planning boards of cities and states operate without the benefits of engineering or technical advice.

Mr. Coes stressed the continuing need for engineers in all forms of community work and urged far greater participation of engineers in government operations.

In Government Policies. There appears to be such a dearth of engineers in elective office as to make such a person a rarity indeed, it was pointed out by James J. O'Donnell, acting director of Maryland's Department of Public Improvement. In fact, no profession which represents so much education, intelligence, ingenuity, and integrity is so poorly represented in the voice of the legislative branch of its government at all levels than the engineer, he said.

"If engineers abstain from political activity, as is apparent from past and present performances, we lose their knowledge and ingenuity in the making of our laws—that does not mean that we get all bad laws, but it does mean that we may have missed an important ingredient that could have improved those laws," Mr. O'Donnell said.

The engineer's reluctance and disdain for public office, according to Mr. O'Donnell, can result only apparently from either of two basic reasons: (1) He is so interested and self-cen-

75th Anniversary Panelists who discussed the basic responsibilities of engineers to their government included: Frank D. Newbury, assistant secretary of defense, Washington, D. C., seated at *left;* R. E. Gillmor, seated at *right,* vice-president, Sperry Corporation, New York, N. Y.; John J. O'Donnell, standing at *left,* acting director of public improvements, State of Maryland; and Harold V. Coes, executive vice-president, Ford, Bacon & Davis, New York, N. Y.

tered in his own pursuits that he does not see fit to look behind the curtain where the policies are made that could some day completely govern those pursuits, or (2) he has an aversion to a class of people known as "politicians" with whom he does not choose to associate. Today, in an era of technical and industrial development of the highest order, the people closest to that development have the least to say about its effect on the public and its use for the general public welfare, he said.

Of course, he added, they are sometimes consulted and questioned and listened to in the committee hearings, but are they always understood? And are their comments and recommendations still alive when that committee acts in closed session, or when a vote is taken on the floor? If instead of such a situation, Mr. O'Donnell advocated, we had one or more able engineers who understood the subject matter, serving on a committee, or present in the legislative chamber to lend the weight of his knowledge to a subject, how much more influence would be exercised toward arriving at a decision that was correct.

Engineer and Prospects for Peace

Training and Use of Engineers in the Communist World. The Soviet Union increased its industrial output more than eightfold in the quarter-century between 1928 and 1953, and has doubled industrial man-hour productivity since 1928.

In spite of these advances, the volume of Soviet manufacturing and mining in 1954 was only about 35 per cent of that of the United States.

These figures were revealed at the second anniversary panel by Russian-born Demitri Shimkin, social-science analyst with the U. S. Department of Commerce, Bureau of the Census.

Mr. Shimkin said that two fundamental considerations dominate the selection, training, and use of physical scientists and engineers in the Soviet Union. The first is the vital role of these specialists in building up Soviet military-economic strength. The other is communist fear of scientists and engineers as potential subversives.

Summing up, Mr. Shimkin said that "the selection, training, and use of physical scientists and engineers in the Soviet Union reveals paradoxical strengths and weaknesses. The application of science on a vast scale is essential to the realization of Soviet ambitions, yet the Communist Party dare not trust the scientist and the engineer. The Soviet Union fears the West, yet depends upon its technology."

Given these circumstances, he said, the following conclusions may be advanced: (1) At the present time, the actual effectiveness of the Soviet Union in scientific innovation and application is far lower than might be indicated by the large number of its physical scientists and engineers, and by the immense Soviet effort, in training and research. (2) In part, this gap lies in the failure to develop and apply increasingly good basic research. Thus Soviet science warrants far closer study by the West than Soviet technology indicates. (3) Beyond this, the Soviets are creating a potential which, given appropriate social changes, might generate a technological revolution. (4) At the present time, the Soviet utilization of Western technology is limited by Western controls on information flow and exports. Moves toward the modification of these controls should be guided by careful assessment of Soviet technological strengths and weaknesses. (5) Finally, scientific and technical publications, including trade journals, are a channel of communication behind the Iron Curtain which the Soviet Union simply must keep open. This fact needs wide exploitation both as a means of insuring a reverse flow of data from the Soviet Union and as a medium for the diffusion of a new hope for a world of peace.

Members of the 75th Anniversary Panel look over the program, prior to discussing the relationship of the engineering profession to the prospects for world peace. Shown, *left to right,* are: Walker L. Cisler, president of Detroit Edison Company, Detroit, Mich., chairman of the panel; Granville M. Read, chief engineer, E. I. du Pont de Nemours & Company, Inc., Wilmington, Del.; Demitri Shimkin, social-science analyst, Bureau of the Census, U. S. Department of Commerce, Washington, D. C.; and John Bell Rae, associate professor of history in the Department of Humanities, Massachusetts Institute of Technology, Cambridge, Mass. The panelists discussed U. S. and Russian training and use of engineers; training and use of engineers in the Western world; and how engineering skills work for peace.

Training and Use of Engineers in the Western World. The growing trend to engineering specialization was defended by Granville M. Read, chief engineer of E. I. du Pont de Nemours & Co., Inc., Wilmington, Del., who has done much to further the latest area of such specialization—atomic energy. He is presently responsible for the engineering of the AEC Savannah River Project.

Mr. Read, who was in charge of design and construction of the Hanford Engineering Works for the production of plutonium, said: "We hear sometimes that this is an age of overspecialization. While I agree that engineers should be well-rounded men, an integrated engineering effort demands specialized knowledge in a great many specific engineering fields."

He added: "We never regiment engineers into a specialty, for we know through experience that this has been ineffective. I don't believe regimentation will even work in Russia."

Engineering Skills Work for Peace. The present-day engineering graduate has about one chance in two of moving into management, according to John Bell Rae, associate professor of history at the Massachusetts Institute of Technology.

Dr. Rae referred to a study he is presently conducting on the engineer as a businessman in the United States and said that one of the significant factors which has emerged is that during the past half-century there has been a steadily increasing flow of engineers into positions of executive responsibility in industry.

Dr. Rae spoke out for an extension of the professional integrity of the engineer into other fields.

He said that there is an underlying philosophy that making a fast buck is not really a desirable goal in life; that what counts is delivering an honest product, whether it be an automobile or an international treaty, whose performance will live up to its promise.

Luncheons and Dinners

President's Luncheon

Speaking at the President's Luncheon on Monday, ASME President D. W. R. Morgan noted that the absence of engineers from politics is conspicuous. Half of the incumbent governors are lawyers, he said, and none are engineers. Only two senators have engineering training.

The trouble with politicians, therefore, Mr. Morgan said, is that most of them are lawyers and lawyers are noted for looking back on old law. On the other hand, he pointed out, the engineer's principle of logic analyses can be helpful in social and political problems—not forgetting the human element.

What the country needs, therefore, he declared, are less backward-looking lawyers and more forward-looking engineers.

Mr. Morgan also touched briefly on the history of ASME and cited some of ASME's contributions to the government and the Armed Forces. For example, he mentioned specifically the work of ASME Research Committee on Munitions Production at the beginning of World War II. This work, he added, included shell-manufacturing practices, forging of shells, fabrication, and finishing and machining of high-explosive steel shell.

A. G. Christie, past-president and Hon. Mem. ASME, presided.

Keynote address of the ASME Diamond Jubilee Spring Meeting was sounded by David W. R. Morgan, *left,* ASME President, at the President's Luncheon. He is shown looking over the official program of the meeting with A. G. Christie, professor emeritus of mechanical engineering, The Johns Hopkins University, and past-president of ASME.

Management Luncheon

It is the poor nations of the world who are discontented and hence inclined to accept the easy promises of communism, H. B. Maynard declared at the Management Luncheon on Tuesday. Mr. Maynard, Mem. ASME, is president of the Methods Engineering Council, Pittsburgh, Pa. Therefore, he said, we must help these nations become richer so that they will love their way of life as much as we do ours. To become rich a country must be productive. Productivity stems from good management. Therefore, he added, our program of extending management know-how is a step in the right direction even though we are perhaps beginning to recognize that because it deals largely with only the material side of life it is far from being the whole answer.

Taking increased productivity as a goal, there were a number of things done which have been most helpful. With the aid of the government, there has been a vast exchange of production know-how. Numerous teams of people from other countries have come to the United States to see how we do things. We have sent many teams of experts to other countries, such as the seminar teams organized by the Council for International Progress in Management, to show others on their home ground how we would go about increasing productivity.

There have been numerous governmental and semigovernmental agencies set up to foster the idea of increased productivity. Nearly every friendly country of the western world now has its productivity center. These started in Europe about 1950. The idea spread to South America shortly thereafter. Now it is extending to Asia, Mr. Maynard said, where recently a productivity center was established in Japan.

In the private field, there has been much activity also. CICS, the International Committee on Scientific Management, has held three International Management Congresses since the end of World War II. It has provided a forum where people from all countries can exchange experiences and ideas on scientific management and has been of incalculable benefit in stimulating fresh approaches to increased productivity.

The one thing that we cannot do, Mr. Maynard declared, is to refuse to recognize the all-important problem we face. Our way of life is at stake. The tide of communism must be turned. Better management is one of the weapons we have to use. Our management know-how, he pointed out, extended to others and properly adjusted to their unique conditions can be an important factor in determining the final outcome of the battle.

L. E. Newman, Mem. ASME, chairman of the ASME Management Division, and manager of education and training services at General Electric Company, New York, N. Y., presided.

General Groves Addresses Banquet

Lieut. Gen. Leslie R. Groves, who supervised development of the first atomic bomb, called for the dispersal of industry and population centers as a necessary first step for defense against atomic attack. General Groves, wartime head of the Manhattan District nuclear-bomb project, addressed a gathering of 500 persons at the banquet on Tuesday evening. He was introduced by Toastmaster Senator Ralph E. Flanders (R., Vt.), a past-president and Hon. Mem. ASME.

Gen. Groves's address appears on pages 486 and 487 of this issue.

General Groves is now a vice-president of Remington Rand, Inc., Stamford, Conn.

"Extending Management Know-How Abroad" was the subject of an address at the Management Luncheon by H. B. Maynard, *right,* consulting management engineer and president of Methods Engineering Council, Pittsburgh, Pa. He is shown with L. E. Newman, *left,* manager of education and training services, General Electric Company, New York, N. Y., who presided at the luncheon.

THE WHITE HOUSE WASHINGTON D C

DAVID W R MORGAN PRESIDENT

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

MY GREETINGS GO TO MEMBERS AND GUESTS ATTENDING THE SPRING MEETING OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. YOU AND YOUR ASSOCIATES ARE CONTINUALLY DEVELOPING MACHINERY THAT INCREASES THE ABUNDANCE OF OUR COUNTRY'S MATERIAL BLESSINGS AND STRENGTHENS THE SECURITY OF THE FREE WORLD. YOU CREATE CAREER OPPORTUNITIES FOR YOUTH AND STIMULATE ECONOMIC GROWTH. I BELIEVE THAT AMERICANS HAVE AN ABIDING CONFIDENCE IN THE SKILL AND IDEALISM OF OUR ENGINEERS—A CONFIDENCE WHICH I MOST CERTAINLY SHARE. I HOPE YOUR MEETINGS THIS YEAR WILL BE A SOURCE OF FRESH INSPIRATION AND KNOWLEDGE.

DWIGHT D. EISENHOWER

During the course of the banquet Granville M. Read, chief engineer of E. I. du Pont de Nemours & Co., Inc., Wilmington, Del., received the 1955 ASME Medal for his outstanding leadership in developing men and in organizing and completing projects of extraordinary national and industrial importance.

While none was present, the following Fifty-Year Members of ASME were also recognized: Julius Alsberg, Washington, D. C.; G. Norwood Comly, Moylan-Rose Valley, Pa.; Frank G. Cox, Wilmington, Del.; Samuel Broadus Earle, Clemson, S. C.; William B. Goentner, Glenside, Pa.; and Walter Hamlin Kniskern, Petersburg, Va.

A high light of the program was the reading of a congratulatory telegram from President Dwight D. Eisenhower by President Morgan.

E. G. Uhl, vice-president of Glenn L. Martin Company was the main speaker at Wednesday's dinner. Subject of Mr. Uhl's address was "The Engineer and the Aviation Industry."

Martin Dinner

ASME members and guests in attendance at the dinner on Wednesday evening, given by Glenn L. Martin Company, heard E. G. Uhl, vice-president of engineering of Martin, list the following points necessary to both a company and its employees: (1) The company must create the proper climate so that the individual can do the best possible job. (2) Management must organize working groups or teams without regimentation. (3) The company should have stability. (4) Proper facilities and machines should be provided but are no substitute for brainpower. (5) The company should provide a service to society. (6) Research should play an important part. (7) A profit should be made—and this will come naturally in a well-balanced and forward-looking company.

Technical Program High Lights

Nuclear Engineering. Proof of rapid progress in the practical application of atomic energy for the generation of power was offered in a number of papers on the 1955 ASME Diamond Jubilee Spring Meeting technical program. The presentations included the fundamental principles and problems encountered in shield designs for nuclear reactors; a feasibility study of benzene as a thermodynamic fluid for the fast breeder reactor; a description of a pilot nuclear-power plant generating 150 kw of electricity from 1000 kw of heat of fission in a circulating aqueous solution of uranyl sulphate; and a discussion of the influence of expended fuel-handling requirements in nuclear-power-plant design.

Other subjects discussed included the basic materials used in the metallurgical problems involved in nuclear-power plants.

One paper discussed the various materials that can be used in the moderator and reflector; in control and shielding; in the structure, cladding, and instrumentation; and as coolants.

In another paper, the selection of materials for components of a sodium-cooled, graphite-moderated reactor was covered. It discussed, in particular, stainless steels and zirconium, and pointed out that the austenitic stainless steels appear to be most satisfactory for use in the sodium system, with the exception of those components located within the reactor core, where the use of zirconium appears to be most suitable.

A third paper covered the role of powder metallurgy in the design of nuclear-power reactors. Discussion centered mainly on the powder metallurgy of beryllium, thorium, uranium, and zirconium, the four "new" metals that play the most important role in nuclear-power reactors.

Finally, the fabrication techniques by which zirconium and its alloys have been successfully made into various product forms were described.

Fifteen years of passenger-automobile design have produced no advance in "crashworthiness" or decrease of traumatic effects when injury-producing accidents occur, according to John O. Moore, director of automotive crash-injury research, Cornell University Medical College, Ithaca, N. Y.

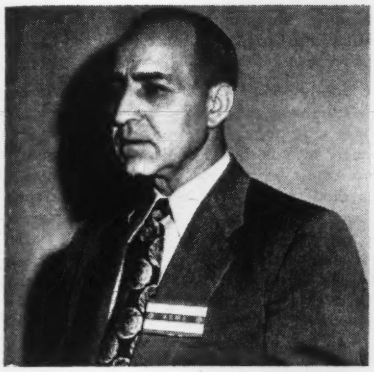
Machine Design. The history of standardizing machined surfaces and a new proposed American Standard For Surface Roughness, Waviness, and Lay was outlined.

Various instruments now make it possible to specify and obtain standard surface roughness. When the manufacturers established standardized degrees of surface roughness they found that this was less costly than trying to obtain an unspecified degree of smoothness at the discretion of the operator. In addition, surface-roughness standards also result in more uniform quality and improve interchangeability of parts, it was said.

Production Engineering. Production-welding principles and new applications for welding such as shielded metal-arc welding, submerged arc welding, inert gas metal-arc welding, spot, seam, and projection welding, and flash welding were covered. Proper application of these processes, it was pointed out, makes possible the manufacture on schedule of functional, well-styled weldments of consistent good quality whose sale and use result in the lowest costs and highest profits to all.

Hydraulics. The many uses and potentialities of water tunnels for hydraulic research were outlined. Water tunnels, it was explained, are classified according to the purposes or uses for which they were primarily built. Thus we have propeller tunnels, tunnels built for studying the forces and cavitation around body shapes, experimental or model tunnels built to improve our knowledge of flow in tunnels and hydraulic equipment, and the like. This paper included a lengthy bibliography on cavitation research and water-tunnel experimentation.

Materials Handling. Belt conveyers for people are already on the drawing boards and



The proposed American Standard for Surface Roughness, Waviness, and Lay and its engineering application in determining roughness values and in the choice of roughness-measuring instruments were discussed by Joseph Manuele, director of headquarters quality control, Westinghouse Electric Corp.

Cost savings in fuel and through reduced maintenance by use of rotary regenerative heaters for shipboard installations were reported by Charles E. Hoch, superintending engineer, Military Sea Transportation Service, U. S. Navy Department, Washington, D. C. He spoke at a Power Division session.

Progress in refueling of aircraft in mid-air was reported to engineers attending the Aviation sessions. Brig. Gen. Benjamin S. Kelsey, deputy director of research and development, USAF headquarters, Washington, D. C., is shown addressing the opening session on this subject.

may soon be in practical use, according to details of a system designed to replace New York's subway run between the Grand Central Station and the 42nd Street, Times Square Station. The conveyer-loading walks running at a speed of $1^1/_2$ mph—slower than normal walking speed—will carry passengers to seats in flat-bottomed cars similar to elevator cages. As the cars leave the loading area, they will contact driven rubber-tired wheels of another conveyer, which will accelerate the cars smoothly to a speed of 15 mph. Traveling at this speed, the cars will, in turn, be transferred to the main conveyer belt, the longest in the entire system, which will maintain the 15-mph speed over the major part of the route. As the cars near the unloading area, they will be transferred to another driven-wheel conveyer, which will decelerate their speed back to $1^1/_2$ mph. At this point, passengers will detrain through automatically opened doors onto the parallel conveyer, which will carry them in a standing position to the street exits.

Basic materials for nuclear-fueled power-plant construction, together with criteria for their selection, were outlined by D. O. Leeser, head of the materials section, Atomic Power Development Associates, Detroit Edison Company, Detroit, Mich. Shown at *left* is the chairman of the session, R. Carson Dalzell, chief metallurgist, Division of Engineering, U. S. Atomic Energy Commission, Washington, D. C.

Aviation. Aerial refueling has become an accepted operational procedure, thanks to the development of some remarkable refueling equipment, it was reported. A description of aerial refueling by means of the Boeing flying boom, revealed that aircraft operated by the Strategic Air Command made 142,000 aerial refueling contacts in 1954. This is the equivalent of one contact every $3^1/_2$ minutes, day and night, in all weather conditions, for every day of the year. SAC considers aerial refueling operations as important as take-offs and landings.

Another paper revealed that low-speed landing, coupled with thrust reversers, may soon eliminate the need for special landing fields with long runways. A pilot-controlled diversion of aircraft power from thrust to lift, and vice versa, to assist aircraft during take-off and landing was described. Proper integration of the major elements—power plant and air frame—would, in an ideal situation, provide means of diverting power automatically or at the pilot's command. According to this paper, reverse thrust braking for jet-propelled aircraft, although still experimental, has been proved feasible by at least three methods.

Power. Use of a thick cellular cross-section revolving metal rotor to transfer waste heat from flue gas to combustion air for marine boilers was described. Known as a rotary-type regenerative air preheater, the device is enclosed in a gastight housing which is fitted at either end to make connection with the air and furnace flue-gas ducts. The cellular heating elements are stacked in the rotor in layers, usually two, seldom more than three. One half of the rotor is exposed to the hot gas and the other half to the incoming cold air. When the rotor is turned slowly, heat is absorbed by the cellular structure as the hot gas passes through, and is then given up to the incoming air as the hot-metal sections revolve into the air stream. Data taken during a trial run of the USNS *Barrett* show that the incoming air temperature was raised about 359 F while the outgoing flue-gas temperature dropped approximately 325 F.

Other papers covered cooling-water treatment and steam-power-plant practice.

Gas-Turbine Power. The 176 Boeing 502-6 gas-turbine engines driving generators after 20,000 operating hours in U. S. Naval Minesweepers were evaluated and summarized. In another paper the procedure followed in developing the Jupiter Series multipurpose gas-turbine engines was discussed and the solutions to various problems were described. A third paper described the static immersion and flow-type tests that were made to determine the relative corrosion-erosion resistance of alloys and coatings to sulphur dewpoint corrosion as found in gas-turbine applications.

Main speakers at the Gas Turbine Power session include, *left to right:* John A. Culver, marine gas-turbine power-plant development engineer, Bureau of Ships, U. S. Navy Department, Washington, D. C.; Amos L. Wood, service manager, gas turbines, Boeing Airplane Company, Seattle, Wash.; Roland L. Coit, development engineer, Westinghouse Electric Corporation, Philadelphia, Pa.; and Ivan M. Swatman, project engineer, Solar Aircraft Company, San Diego, Calif.

Management. A technique to assist executives in making a decision involving a multitude of intangible factors was outlined. Decisions based in part on the executive's intuition, it is said, are generally less secure than those based upon a simple balancing of numerical factors. By this technique many of the so-called intangibles, which are often judged by intuition, can be reduced to a simple numerical expression. The technique consists of multiplying the approximate cost of an individual event by the probable number of times it will occur.

Metals Engineering. Ultrasonic tests for internal flaws in metals are being extended successfully with automatic recording to the inspection of small-diameter tubing, it was disclosed. The new method contributes to maximum safety in the construction of atomic-power plants. The necessity for more stringent inspection than has been required by applicable ASTM specifications has been recognized in view of the serious consequences of failures attributable to materials defects that cannot be detected in any other way. The removal of limitations on the method as applied to tubing will be of value for inspecting all tubing to be subjected to severe service conditions. Solution of one of the basic problems in applying the ultrasonic-test method to small objects was attained by means of a delayed shear-wave search unit, along with the technique of using the recording equipment. Although the equipment was developed for acceptance tests of tubing, its greatest usefulness is believed to be as a quality-control tool in tubing producers' plants.

Instruments. An instrument that will produce flight records automatically under all conditions of flight—including crash—is now available to the industry and may become compulsory equipment on all aircraft. The device, known as the General Mills Ryan flight recorder, automatically measures the indicated air speed, static pressure altitude, vertical acceleration, compass heading, and time. The time of any event desired for record may be marked by the pilot. The instrument makes it possible to preserve records for the evaluation of aircraft performance, stresses encountered in flight, techniques, severe atmospheric disturbances, landing shocks, and other flight conditions. The result is to "insure that an air failure need only occur once to prevent its recurrence."

Safety. Four steps for a solution of America's highway toll of accidents were listed in a paper on safety: (1) Consistent and complete safety records should be kept. (2) These records must be evaluated by proper statistical methods which will permit us to interpret these data in terms of their rate (number of people involved, man hours, car miles, and so on) and variability (the number of cases on which they were based). (3) A conscious effort should be made to determine the effectiveness of aspects of safety program, since it appears likely that some phases of current safety programs produce no obvious effect. (4) Special attention should be paid to studying undue practices as well as accidents, since there are elements in any safety program which do not show up as accident data, but which probably help to produce accidents.

Other papers covered fuels, process industries, applied mechanics, and metals processing. In addition, the Education Committee sponsored a panel on engineering and good citizenship and the National Junior Committee at its session discussed the engineer as a public employee.

Digests of 35 of the preprinted papers are published in the ASME Technical Digest section of this issue of MECHANICAL ENGINEERING.

Inspection Trips and Committees

Inspection Trips

Six interesting inspection trips were arranged for members and guests attending the Spring Meeting to government installations and industrial plants in the Baltimore area. On Tuesday, members and guests were shown the Mt. Clare shops and the Transportation Museum of the Baltimore and Ohio Railroad.

Among the hundreds of exhibits of original old locomotives and life-sized models of cars, engines, and railroad tracks were displays of Sir Isaac Newton's Engine, The Stourbridge Lion, The Pioneer Horse Car, The Tom Thumb, and Two Iron Boxcars designed to haul ammunition during the Civil War.

Two trips were scheduled on Wednesday. The first was a tour of the Chevrolet and Fisher Body Divisions of General Motors where guests were shown the complete assembly of an automobile. The other trip was to the Gunther Brewing Company. The tour showed the making of beer from basic raw material to finished product as well as its canning and bottling.

The Riverside Power Plant of Consolidated Gas Electric Light and Power Company of Baltimore was inspected on Thursday. During the tour the turbine-generators and boilers were seen in regular operation, together with coal-handling equipment, coal pulverizers, and other equipment used in this power plant.

All-day tours of two government installations were scheduled for Friday. Visitors were taken on a tour of the Ballistic Research Laboratories' Wind Tunnel, Electronic Computing Laboratory, and Weapons Museum at the Aberdeen Proving Ground, Aberdeen, Md. The second tour was to the U. S. Naval Academy and Engineering Experiment Station, Annapolis, Md. Visitors were taken around the Naval Academy grounds. Open for inspection were the many research facilities of the Station including diesel engines, pumps, marine-propulsion devices, and many others.

Committees in Charge

The committees in charge of arrangements for the Diamond Jubilee Spring Meeting included the following: *General Arrangements:* Arthur M. Gompf, *chairman;* Louis E. Carter, *vice-chairman;* Ernest H. Hanhart, *vice-chairman;* and Sears Williams, *chairman* for American Rocket Society; *Entertainment:* Edward J. Morris, *chairman; Finance:* Kalman Steiner, *chairman; Hotel:* Louis E. Carter, *chairman; Information and Registration:* Robert E. Shreeve, *chairman; Ladies:* Mrs. E. H. Hanhart, *chairman;* Mrs. E. W. Sciff, *co-chairman;* Mrs. L. E. Carter, Mrs. R. W. Davies, Mrs. R. C. Dannettel, Mrs. A. M. Gompf, Mrs. G. S. Harris, Mrs. A. L. Penniman, Jr., Mrs. S. B. Sexton, 3rd, and Mrs. R. E. Shreeve; *Plant Trips:* Samuel B. Sexton, 3rd, *chairman; Printing and Signs:* Ralph W. Miller, *chairman; Publicity:* Louis G. Smith, *chairman; Reception:* Abbott L. Penniman, Jr., *chairman; Technical Events:* Ernest H. Hanhart, *chairman; 75th Anniversary Committee:* Jess H. Davis, *chairman;* A. C. Pasini, Otto de Lorenzi, E. W. Jacobson, and R. B. Smith.

ASME Organization Anniversary Meeting Celebrated at Stevens Tech

- **Educational Institutions and Professional Societies Extend Greetings**
- **Engineering Education and Training Discussed**

DEVOTED to the theme, "The Engineer and the World of Education," The American Society of Mechanical Engineers celebrated the 75th Anniversary of its organization at a meeting on April 16, 1955, at Stevens Institute of Technology, Hoboken, N. J. The affair commemorated the meeting in 1880, on the same campus, at which 85 engineers gathered to elect a slate of officers and adopt the by-laws and constitution of the new Society, now grown to a membership of some 40,000.

The day-long program opened with a convocation in the same auditorium (now completely modernized) in which the founders of ASME first met 75 years ago. Arthur S. Adams, president of the American Council on Education was the principal speaker at a luncheon. A panel discussion on the theme, The Engineer and the World of Education, rounded out the day's activities.

Convocation

Speaking at the convocation in the morning both D. W. R. Morgan, president of ASME, and Jess H. Davis, president of Stevens, agreed that the fully automatic factory of the future holds great promise for American engineers and scientists.

Dr. Morgan, in his presidential address, said that automation and electronic computers would increase the need for creative engineers able to do basic research work.

"By eliminating routine work," he said, "more time can be spent on fundamental and applied research and applied engineering development."

He was joined in this viewpoint by Dr. Davis, who said in his address of welcome, that it is not merely the fact that the machines will make uniformly excellent products at prices greater multitudes can afford; rather, it is that the machines will free from more routine tasks of industry engineers and scientists whose trained and thirsty minds can be turned to more weighty problems.

Dr. Davis praised modern engineering students saying that "their power of analysis is much more keenly developed and enables them to start their professional careers at a far higher level than their apprenticed predecessors, depending almost entirely on intuition and experience, could ever hope to attain."

Dr. Morgan urged engineering students to concentrate more on the basic sciences at the expense of applied engineering which, he said, can be taken up later in industry.

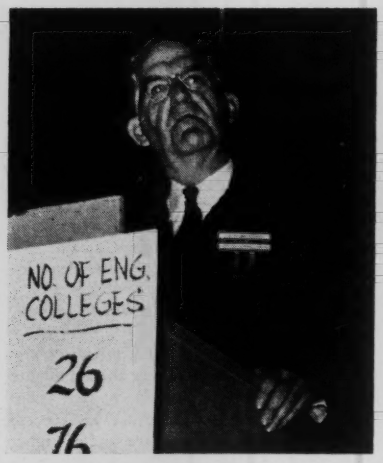
He also urged students not to attempt any degree of specialization during their graduate work.

He pointed out that only six per cent of U. S. high-school graduates have studied higher mathematics, science, and physics. He called for immediate action in developing plans at the local level to insure a better understanding of educational needs.

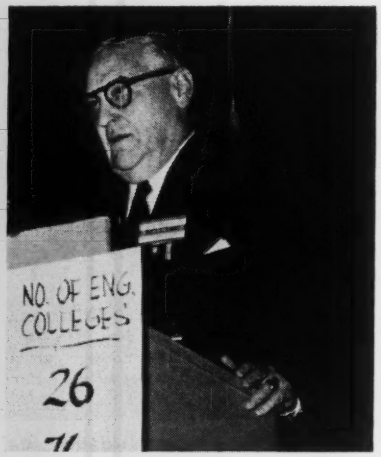
Greetings Extended to ASME

Greetings to ASME were presented by representatives of 42 other engineering organizations in the United States and abroad, 152 colleges and universities, 10 engineering frater-

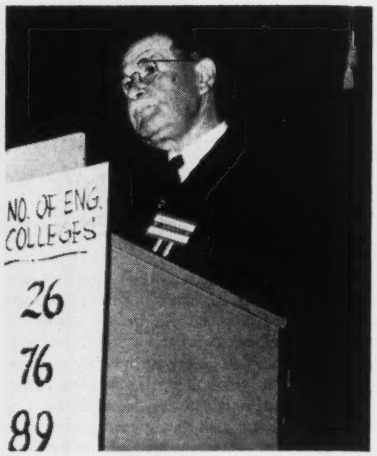
Shown during the panel session on "The Engineer and the World of Education" are *left to right:* A. G. Christie, moderator; D. W. R. Morgan, chairman of the session; and panelists C. Richard Soderberg, who spoke on engineering education abroad; Blake R. Van Leer, who covered American engineering education; Mervin J. Kelly, whose subject embraced postgraduate training of engineers; and Joseph M. McDaniel, Jr., who spoke on the role of foundations in the field of education



W. R. Glidden, president of the American Society of Civil Engineers, gave the congratulations of engineering societies and joint bodies



Greetings to ASME on behalf of universities and colleges were presented by Livingston W. Houston, president of Rensselaer Polytechnic Institute



Greetings to the Society on behalf of engineering fraternities were presented by Harold M. King, president of Tau Beta Pi

nities, and the American Council on Education.

Congratulations were tendered on behalf of universities and colleges by Livingston W. Houston, president of Rensselaer Polytechnic Institute; on behalf of engineering societies and joint bodies by W. R. Glidden, president, American Society of Civil Engineers; and on behalf of engineering fraternities by Harold M. King, president of Tau Beta Pi.

Adams Addresses Luncheon

Arthur S. Adams, president of the American Council on Education and principal speaker at the Organization Anniversary Luncheon, presented greetings to ASME on the occasion of its 75th Anniversary, on behalf of the American Council on Education, which numbers 1100 members including 960 educational institutions. He stated his respect for ASME and for its contributions to the world of education.

In his address Dr. Adams noted that there are three truly major events in the history of man: (1) The invention of the wheel, making possible the application of human and animal energy on a more efficient basis; (2) the application of the expansive power of gases and vapors, put to work in the steam engine which led to the industrial revolution and the electrical development; and (3) the era of atomic energy.

The significant thing, he said, is the rapid acceleration of progress in the case of the last two developments. Real progress, he said, has been made in the period since the birth of ASME in 1880.

The three great inventions in the history of man—the wheel, the steam engine, and atomic energy—have been made possible largely by mechanical engineering, Dr. Adams declared.

The application of expansion power is basic to electric production. Hydraulic power would never have sufficed for all our needs. Use of electricity has been important not merely because it is an efficient form of power, but because it has for the first time made it possible to distribute power (and its benefits) to every corner of the earth. This will continue to be true in the atomic era.

He reviewed the contributions of the early ASME heroes—Holley, Durand, Cooley—in the history of the Society, including Robert Henry Thurston, first president of ASME, who was head of the mechanical-engineering department at Stevens Tech. He noted that many of them had served in the Navy, and said that the United States Congress may have contributed significantly—if unwittingly—to the progress of mechanical engineering in this country by passing legislation making it possible for graduates of the Naval Academy to teach courses in mechanical and marine engineering in civilian institutions.

The Act was passed in 1879, one year before ASME's founding. It was then, he said, that the mechanic arts became what is known today as mechanical engineering. The Navy men were able to translate the practical experiences of sea operation of steam-power equipment into the principles of mechanical engineering.

Development of organized curriculums in mechanical engineering began in the 1880's, during the first years of the Society, Dr. Adams noted. We came to recognize the relationship between engineering and the physical sciences.

ASME President D. W. R. Morgan, *right,* presents plaque to Jess H. Davis, president of Stevens Institute of Technology. The plaque commemorates the Organization Meeting of ASME at Stevens on April 7, 1880.

Out of the proliferation of achievement of engineers—especially the accelerated achievement of the past 75 years—there has been developed a conscience in respect to the profession. Dr. Adams did not refer so much to the matter of professional ethics, as to the fact that engineers now consider what impact on society and engineering application will have.

Holley Medal to Shewhart

A feature of the luncheon program was the presentation of the 1954 Holley Medal to Walter A. Shewhart for his unique genius in pioneering the application of statistical methods to the control of the quality of manufactured products, an epoch-making contribution to economical mass production.

Dr. Shewhart is a research statistician with the Bell Telephone Laboratories, Murray Hill, N. J.

Dr. Shewhart was one of the participants in a historic meeting held in New York on Dec. 5, 1929. The result of that meeting was the establishment of a joint committee of the American Statistical Association, the American Mathematics Society, the American Society for Testing Materials, and ASME. That committee, which disbanded last year after 25 years' service, is credited with pioneering the application of statistical methods for quality control.

In his speech of acceptance, Dr. Shewhart pointed out that Stevens Tech in 1930 offered the first course in quality control ever presented outside the Bell system.

Also introduced during the luncheon meeting were the following six "Fifty-Year Members of ASME:" Norman C. Chambers, New York, N. Y.; Allen S. Crocker, Rochester, N. Y.; Samuel Bovard Daugherty, Orchard Park, N. Y.; Benjamin Stuart Murphy, Jersey City, N. J.; Francis Benjamin Northrup, Nutley, N. J.; and Frederick Edward Town, South Orange, N. J. Only Mr. Murphy was present and he was presented with a 50-year button by Dr. Morgan.

L. F. Grant, president of Engineers' Council for Professional Development, acted as toastmaster. He was presented with a special 75th Anniversary award.

Toastmaster, L. F. Grant, president of ECPD, gets ASME Organization Anniversary Luncheon Program under way

Walter A. Shewhart, *center,* is shown receiving Holley Medal from ASME President D. W. R. Morgan, *left.* At *right* is Eugene W. O'Brien, past-president and Fellow ASME and chairman of the Board on Honors, who presented Dr. Shewhart with the medal.

Arthur S. Adams, feature speaker at the luncheon, presents greetings to ASME on behalf of the American Council on Education

Engineering Education and Training

Problems of engineering education and training took the limelight at the afternoon panel as four experts analyzed The Engineer and the World of Education. Speakers were Blake R. Van Leer, president of Georgia Institute of Technology; C. Richard Soderberg, dean of engineering at Massachusetts Institute of Technology; Mervin J. Kelly, president of Bell Telephone Laboratories; and Joseph M. McDaniel, Jr., secretary of the Ford Foundation.

Dr. Van Leer reviewed the status of engineering education in America. He pointed out that in 1880, the year in which ASME was founded, there were 185 institutions offering engineering degrees, with a total enrollment of approximately 1000. Today, there are 218 such institutions, with a total enrollment of more than 187,000.

Dr. Soderberg discussed engineering education abroad. He concluded that the performance of American trained engineers, once the graduate is seasoned by a few years of experience, is approximately on a par with that of European trained engineers.

Dr. Kelly talked on postgraduate training of engineers in industry. He said that the past 15 years have seen a tenfold increase in the nation's effort in creative technology, with 150,000 to 170,000 graduate engineers and scientists being employed on research and development projects, as opposed to 20,000 in 1939.

Dr. McDaniel outlined the role of a philanthropic foundation in modern education. He said that the elementary school must prepare for a 50 per cent increased enrollment within the next seven years, and that secondary school enrollment will be 75 per cent higher in 1965. College enrollment, he predicted, will be 100 per cent higher in 1970.

"What we face," he said, "is the task of doubling in 15 short years the capacity of all the higher educational institutions which it took this nation 300 years to build."

A. G. Christie, past-president and Hon. Mem. ASME, served as moderator.

A reception at Castle Stevens climaxed the day's events.

First ASME IRD Conference Proves a Big Success

INDICATIVE of the growing interest and activity in the field of automatic control is the holding of the first annual Instruments and Regulators Division Conference by The American Society of Mechanical Engineers on the campus of The University of Michigan in Ann

Ed Sinclair Smith of the Army Ordnance Corps, Aberdeen, Md., receives an IRD Award at second Conference Luncheon

A. C. Pasini, an ASME Director, speaks on the professional growth of engineers at second IRD Conference Luncheon

Arbor, Mich., on April 25 and 26. Two hundred engineers and technicians attended the sessions which were sponsored in co-operation with the ASME Detroit section. Eight technical papers were presented in four sessions. There were special luncheons on Monday and Tuesday, with a banquet on Monday evening.

Luncheon Speakers

Speaker at the Tuesday luncheon in The Michigan League was Albert C. Pasini, an ASME Director, who is associated with The Detroit Edison Company. In his speech, which is entitled "A Few Accomplishments of Our Profession," Mr. Pasini made a strong plea for greater participation by engineers in the activities of the Engineers' Council for Professional Development, which was established in 1932 to promote the welfare of individual engineers working in any branch of the profession. ECPD now represents eight national engineering organizations with a total membership of approximately 200,000.

Pointing out the important role which engineers have played in developing the resources at man's disposal, Mr. Pasini observes that modern progress "no longer waits on genius—instead we have learned to place our faith in the organized and co-ordinated efforts of ordinary men. To this idea the engineer has been a major contributor." Mr. Pasini believes, however, that engineers must not shun political responsibilities if they are to maintain effectively their professional standing. At this luncheon Ed Sinclair Smith of the Army Ordnance Corps, Aberdeen, Md., received IRD Award in recognition and appreciation of his initiative, inventive genius, and original contributions to the ASME.

Dean George Granger Brown of the University of Michigan College of Engineering spoke at the luncheon on Monday, April 25, and John E. Arnold, associate professor of mechanical engineering at Massachusetts Institute of Technology, delivered an address at the banquet in The Michigan Union on the subject of "Creativity in Science and Engineering."

Availability List for 1955 ASME Instruments and Regulators Conference

THE PAPERS in this list are available in separate copy form until Feb. 3, 1956. Please order only by paper *number;* otherwise the order will be returned. Copies may be purchased from the ASME Order Department, 29 West 39th Street, New York 18, N. Y.; 25 cents per copy to ASME members; 50 cents to nonmembers.

Paper No.	*Title and Author*
55—IRD-1	Determination of System Characteristics From Normal Operating Records, by T. P. GOODMAN and J. B. RESWICK
55—IRD-2	Disturbance Response Feedback—A New Control Concept, by J. B. RESWICK
55—IRD-3	Improving Airplane-Handling Characteristics With Automatic Controls, by C. L. MUZZEY
55—IRD-4	Study of Pneumatic Processes in the Continuous Control of Motion With Compressed Air-I, by J. L. SHEARER
55—IRD-5	Dynamic Analysis of Chemical Processes, by E. G. HOLZMANN
55—IRD-6	Improved Process Control From Noninteracting Controller Design, by D. P. WAITE
55—IRD-7	Control of Surge in Centrifugal Compressors, by G. J. FIEDLER and T. F. MCGRATH
55—IRD-8	Evaluation of the Nonlinear Kinetic Behavior of a Nuclear-Power Reactor, by R. C. HOWARD

Kansas-Missouri Sections Celebrate ASME's 75th Anniversary[1]

A SPECIAL Diamond Jubilee meeting of The American Society of Mechanical Engineers was held Wednesday, April 13, 1955, at the University of Missouri under the joint auspices of the Kansas City and St. Louis Sections, together with the ASME Student Branches at Kansas State College, the University of Kansas, Missouri School of Mines, Washington University of St. Louis, and the University of Missouri. The meeting was also the occasion for the presentation of the Holley Medal to Prof. George J. Hood.

The Holley Medal

The Holley Medal was initiated in 1920 by George I. Rockwood, Hon. Mem. ASME, and later its vice-president. He proposed that the Society establish an award in the form of a gold medal to be given to an engineer for distinguished service in engineering and science. The Council accepted his suggestion and voted to have the first award made in Dec. 7, 1921, to Hjalmar G. Carlson, even though the medal was not endowed or ready at that time.

For the time being, the award was called the Great Achievement Gold Medal. Later, at the request of Mr. Rockwood, this gold medal was named the Holley Medal in honor of Alexander Lyman Holley, one of the founders of ASME and the man responsible for bringing the bessemer process of steelmaking to this country. The medal was endowed by Mr. Rockwood in 1924, and the first medal was struck and awarded to Mr. Carlson the same year.

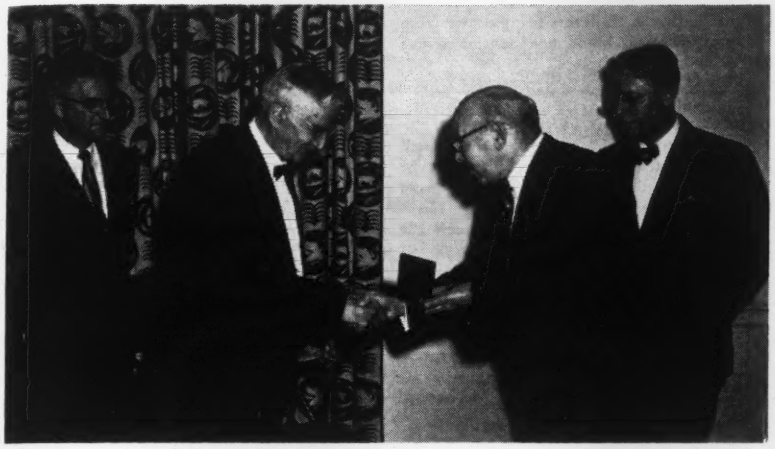
[1] W. C. Boteler, Junior Class, University of Missouri, Student Mem. ASME.

G. J. Hood Receives Holley Medal

The Holley Medal was awarded, on this occasion, to George J. Hood, professor emeritus of the University of Kansas School of Engineering, for his outstanding humanitarian service in the invention and development of the dermatome, a skin-grafting instrument for surgical treatment of severe burns. The device, which will cut accurate skin grafts as large as 15 × 8 in. and of uniform predetermined thickness from 5 to 50 thousandths of an inch, has already saved thousands of lives throughout the world.

A native of Chicago, where he was born in 1877, Professor Hood taught engineering draw-

President Morgan presents the 75th Anniversary Student Award to John B. Miles. The younger Miles was presented for the award by his father, Dr. Aaron J. Miles, chairman, department of mechanical engineering, Missouri School of Mines.



President Morgan presents the Holley Medal to Professor Hood. *Left to right* are: Clifford Shumaker, vice-president, ASME Region VI; Prof. G. J. Hood, professor emeritus of University of Kansas, School of Engineering; President D. W. R. Morgan, ASME; and Ralph Scorah, toastmaster.

ing at the University of Kansas from the time of his graduation there with a BS degree in 1902 until his retirement in 1947. In 1917 he received a degree in mechanical and was appointed full professor. He is the author of "Descriptive Geometry by the Direct Method" (three editions) and of the well-known textbook, "Geometry of Engineering Drawing."

Other valuable inventions by Professor Hood include gas engines, a gas-explosive pump, drawing instruments, an autographic device for the film pack, and a photographic method for producing perspective layouts from aircraft sections.

He is a member of Sigma Xi, Tau Beta Pi, and Alpha Tau Omega. The American Society for Engineering Education, of which he is also a member, honored him in 1952 with their Distinguished Service Award.

Five Receive Student Awards

The meeting was also the occasion for the presentation of the Seventy-Fifth Anniversary Student Awards to the outstanding engineering students of colleges having ASME Student Branches in the Missouri-Kansas area. The recipients were Everett Hart of Kansas State College, Dwight H. Harrison of the University of Kansas, John B. Miles of the Missouri School of Mines, Thomas L. Kick of Washington University of St. Louis, and Donald Crawford of the University of Missouri.

The banquet, preceded by a reception, was held in the Memorial Student Union Building of the University of Missouri. The program for the evening opened with introductions by the toastmaster, Ralph Scorah, professor, chairman of the department of mechanical engineering, University of Missouri.

President Morgan presented the Student Anniversary Awards to the student medalists, who, with exception of one, were introduced by the Honorary Chairmen of their Student Branches. That noteworthy exception was John Bruce Miles who was introduced by his father, Dr. Aaron J. Miles, Mem. ASME, chairman of the mechanical-engineering department at the Missouri School of Mines.

Prof. George J. Hood was then introduced by Professor Shumaker and was presented with the Holley Medal by President Morgan.

In his response, Professor Hood expressed his deep appreciation to the Society for this great honor, saying,

"To receive the Holley Medal is a great and satisfying honor.

"Through the years, I have read about the awards of the Holley Medal, but never with the trace of a thought that some day it might come my way.

"And, then, a letter from President Morgan notifies me.

"I had to read that letter several times before I could believe it.

"Of course, I am pleased. Who wouldn't be?

"And you young students who have received your medals today, may you some day also receive the Holley Medal.

"My thanks to all of you."

President Morgan Speaks

Dean H. O. Croft introduced the speaker of the evening, President Morgan, whose address was entitled "The Student Engineer in Our World." He described the growth of the Society and of the profession in parallel with the growth of our great nation in the past 75 years.

He pointed out that the Society has, in this year of 1955, rededicated themselves to their original purpose: "By Truth and by Service to Enrich Mankind." He then addressed his remarks to the student engineers, recommending that they not be too hasty to specialize. He enumerated those things which industry and their future employers have a right to expect of them.

President Morgan pointed out that the student must, upon graduation, establish his own objectives and his own program for personal development. He gave several points which such a program should include and closed with a call for more engineers to take part in policy-making capacites in national affairs.

Some penetrating closing remarks were provided by Ben George Elliott, vice-president of Region VI of the ASME and by Clifford Shumaker, vice-president of Region VIII of the ASME. Professor Elliott took this opportunity to plug Chicago, Ill., of course, as an ideal site for the location of ASME National Headquarters. Professor Shumaker served several rare bits of Texas humor as a cordial. President Morgan returned to the lectern to express his deep and sincere thanks to Ben Elliott and Clifford Shumaker for their great work in behalf of our Society.

Then Professor Scorah closed the meeting with a note of appreciation to T. A. Marshall, Jr., assistant secretary of the Society, for his efforts in behalf of the meeting and for the special souvenir programs.

Recipients of the ASME 75th Anniversary Student Award, shown *left to right,* are Thomas L. Kick, Washington University; John Bruce Miles, Missouri School of Mines; Everett T. Hart, Kansas State College; Dwight H. Harrison, University of Kansas; and Donald Crawford, University of Missouri

Igor Sikorsky, Fellow ASME, boarding plane at Idlewild, N. Y., for England to receive the James Watt International Medal of The Institution of Mechanical Engineers. Dr. Sikorsky was the ASME nominee for the honor. On April 29, following the presentation of the medal, Dr. Sikorsky delivered the James Clayton Lecture entitled "The Transport Helicopter," in which he predicted an interesting future for the helicopter. He stated that development of the transport helicopter will follow two main lines for both military and commercial use: The first will correspond to the airliner or transport airplane, while the second will be a freight and cargo carrier.

1955 Heat Transfer and Fluid Mechanics Institute Program Announced

THE 1955 Heat Transfer and Fluid Mechanics Institute continues with the purpose established during a seven-year history of presenting technical and scientific advances in fluid mechanics, heat transfer, and related fields. Emphasis is given to topics covering more than one specific field, that is, to topics which do not fall uniquely into one or another of the conventional categories, such as aeronautical, chemical, or mechanical engineering. The prime objective of the Institute is to provide a focal point where contributions to the scientific advancement and intellectual growth of the Western community may be exchanged. This objective has been accomplished with notable success with papers being drawn from many of the research and development centers across the nation.

Proceedings

Copies of presented papers will be distributed to Institute attendees. Proceedings may be obtained after the Institute by ordering from Stanford University Press, Stanford, Calif. Preprints will not be available through the ASME Order Department.

The Institute is sponsored by California Institute of Technology; Stanford University; University of California, Berkeley and Los Angeles; University of Santa Clara; and University of Southern California; in co-operation with several national professional societies including The American Society of Mechanical Engineers.

Institute Program

THURSDAY, JUNE 23

9:30 a.m.–12:15 p.m.

Session 1

Chairman: C. B. Millikan, California Institute of Technology, Pasadena, Calif.

Introduction: Myron Tribus, general chairman, 1955 Heat Transfer and Fluid Mechanics Institute.

Interaction of Shock Wave and Turbulence, by *L. S. G. Kovasznay,* The Johns Hopkins University

Structure of Shock Waves in Polyatomic Gases, by *Wayland Griffith,* Princeton University

Contributions on the Mechanics of Boundary-Layer Transition, by *G. B. Schubauer* and *P. S. Klebanoff,* National Bureau of Standards, Washington, D. C.

2:15 p.m.–5:00 p.m.

Session 2

Chairman: Harold Luskin, Douglas Aircraft Co., Santa Monica, Calif.

Effects of High Acceleration on a Turbulent Supersonic Shear Layer, by *M. Morkovin,* The Johns Hopkins University

Separation of Supersonic Turbulent Boundary Layers, by *S. M. Bogdonoff,* Princeton University

Heat-Transfer Analysis and Boundary-Layer Measurements of Flow in Supersonic Nozzles, by *M. Sibulkin,* Jet Propulsion Laboratory, California Institute of Technology

Laminar Heat-Transfer Characteristics of a Hemisphere for Mach Number Range 1.9 to 4.9, by *I. Korobkin,* Naval Ordnance Laboratory, Silver Springs, Md.

FRIDAY, JUNE 24

9:30 a.m.–12:15 p.m.

Session 3

Chairman: R. A. Seban, University of California, Berkeley, Calif.

On Mechanics for High-Frequency Combustion Instability, by *D. E. Rogers* and *F. E. Marble,* Jet Propulsion Laboratory, California Institute of Technology

Supersonic Diffuser Instability, by *C. L. Dailey,* University of Southern California

Cone Drag in a Rarefied Gas Flow, by *D. C. Ipsen,* University of California, Berkeley

2:15 p.m.–5:00 p.m.

Session 4

Chairman: Duncan Rannie, California Institute of Technology, Pasadena, Calif.

Flow in Corners of Passages With Noncircular Cross Sections, by *E. R. G. Eckert* and *T. F. Irvine, Jr.,* University of Minnesota

On Turbulent Flow Near a Wall, by *E. R. Van Driest,* North American Aviation, Downey, Calif.

Shear Transmission From a Turbulent Flow to Its Viscous Boundary Sublayer, by *H. A. Einstein* and *Huon Li,* University of California, Berkeley

Velocity and Pressure Distribution in Turbulent Pipe Flow With Uniform Wall Suction, by *H. L. Weissberg* and *A. S. Berman,* Carbide and Carbon Chemicals Corp., Oak Ridge, Tenn.

SATURDAY, JUNE 25

9:30 a.m.–12:15 p.m.

Session 5

Chairman: A. Louis London, Stanford University, Stanford, Calif.

Atmosphere Pollution With Application to Los Angeles Area, *by F. Frenkiel,* Applied Physics Laboratory, The Johns Hopkins University, Silver Springs, Md.

The Steady Axially Symmetric Flow of a Viscous Fluid in a Deep Rotating Cylinder Which is Heated From Below, by *G. N. Lance* and *E. C. Deland,* University of California, Los Angeles

Laminar Flow With Injection and Suction Through Porous Wall, by *S. W. Yuan* and *A. Finkelstein,* Polytechnic Institute of Brooklyn, Freeport, N. Y.

2:15 p.m.–5:00 p.m.

Session 6

Chairman: Robert Bromberg, Ramo-Wooldridge Corporation, Los Angeles, Calif.

On Panel Flutter in a Compressible Flow, by *J. W. Miles,* University of California, Los Angeles

Some Factors Affecting Fluidity of Metals, by *D. Ragone,* University of Michigan; *C. M. Adams* and *H. F. Taylor,* Massachusetts Institute of Technology

A Deceleration Probe for Measuring Stagnation Pressure and Velocity of a Particle-Laden Gas Stream, by *J. L. Dussourd,* AiResearch Manufacturing Company, Los Angeles, Calif.; and *A. H. Shapiro,* Massachusetts Institute of Technology

ASME Exposition of Power and Mechanical Engineering Announced

ANNOUNCEMENT has been made that the Chicago Exposition of Power and Mechanical Engineering will be held in the Chicago Coliseum, November 14 to 18, under the auspices of The American Society of Mechanical Engineers and in conjunction with the 75th Anniversary Meeting. Space reservations are already being made for the display, which will be located only a short distance from the hotels where the ASME meetings will be held.

The advisory committee has been announced. I. E. Moultrop is chairman of the committee, which is composed of men of distinction in many engineering fields and representatives of the Society. John H. Lawrence is vice-chairman.

Representatives of the ASME on the Committee are the following: D. W. R. Morgan, President, ASME; A. C. Pasini, The Detroit Edison Company; G. A. Hawkins, dean of engineering, Purdue University; Robert B. Lea, co-ordinator of exports, The Sperry Corporation; Alex D. Bailey; J. H. Davis, president, Stevens Institute of Technology; J. D. Cunningham, president, Republic Flow Meters Company; Ronald B. Smith, vice-president, The M. W. Kellogg Company; Roland W. Flynn, division lubrication engineer, Gulf Oil Corporation; C. E. Davies, secretary, ASME.

Early reservations of exhibit spaces assure a representative display of equipment covering every phase of power generation and industrial use. The exposition is being managed by International Exposition Company, 480 Lexington Avenue, New York 17, N. Y.

Junior Forum . . .

Conducted by R. A. Cederberg,[1] Assoc. Mem. ASME

The Engineer as a Public Employee

Report on the Baltimore Junior Session by Arthur E. Lundvall, Jr.[2]

HIGH LIGHTS of the Junior Session at the 1955 ASME Spring Meeting centered about discussions by Samual S. Baxter, Water Commissioner for the City of Philadelphia, and Henry A. Barnes, Director of Traffic for Baltimore City. The theme of the meeting was, The Engineer as a Public Employee.

The Challenge of Public Employment to the Engineer

Mr. Baxter based his presentation on several questions that the young engineer might ask prior to embarking upon a career as a public employee. "What is so challenging in public employment? Why should an engineer submit to the unfair criticisms that come to many people in public life? What return does the engineer get from public employment, as compared to private employment?"

Answers to these questions were immediately forthcoming. That there was ample work to be done by engineers in public employment was brought out by a brief outline of the ever-present engineering tasks facing municipal, state, and federal governing bodies. The engineer has important responsibilities in the conception and the preliminary planning of varied works. These responsibilities necessarily include the fields of finance, budgeting, administration, personnel, public relations, and other management functions.

"As I see it, there are two distinct challenges," said Mr. Baxter. "The first challenge concerns the physical work itself. Take the matter of treatment of domestic and industrial sewage for which the Office of the Surgeon General indicates $25 billion of work is needed in the next ten years. Design work on projects of this sort includes such things as population studies, methods of treatment, structural design of plants and pumping stations, the design of pumps, switch-gear, and other mechanical work. Construction takes the best skills of men not only in the field but in the industrial plants where standard and special equipment of many types must be manufactured. When the plant is placed in operation, such operation must be managed and directed by trained engineers and scientists."

Mr. Baxter went on to say that he considered the second challenge to be less easily defined. "It deals with the 'whys' of the work, the needs of people, and the relationship of the government engineer to the public at large." Reference was made to the story in the New Testament, of Mary and Martha, and it was pointed out that we as engineers and builders of material things may be considered sons of Martha. "We build things to enable us to have more of the better physical things of life, to enjoy comforts and even luxuries, to provide facilities to grow more and better food. The list is endless. The engineer is certainly in the forefront of those who supply the physical needs of our civilization, and this applies to many of the engineering functions which are the responsibilities of governmental units." By dint of the moral obligation that the profession places upon him the engineer in public service is a man dedicated to his job "serving both the inner and outer man." The challenge of public service to the engineer is great. He should see far beyond the structure which he is designing, building, or operating. If he has any vision at all, he is imbued with the idea of service to the people in his community.

It was brought out that the idea of service to our fellow man may not be so out-of-date, and references were made to individuals in other professions who are devoted to the service of others. "This is where the real challenge of public engineering enters the picture. The engineer in public service, except in rare cases, must get his reward and satisfaction by some other means than by cash or property. He must get part of his satisfaction in knowing that he performs a real service to his community and the people in it."

As the discussion progressed, it became apparent that government at all levels needs men of strong will with honest and sincere principles. The engineer should and can bring such principles to the over-all field of government. He has the training and the capacity to marshall facts, to apply basic laws, and come up with a practical and economical solution.

"If our engineers will increase their efforts to combine those traits with some human and social thinking, there would be few who could approach him in attacking many of today's governmental problems."

Turning to the question of the return the engineer can expect from public employment, Mr. Baxter stated that while most public agencies are liberal with sick leave and vacation time, private industry has increased its benefits to a point where the differential is now quite small. Security of position is sometimes considered one of the benefits of public employment. "However," warned Mr. Baxter, "undue emphasis on security has a stifling effect on the individual and also on the job he performs. The engineer in public employment should be willing, on occasion, to stick his neck out to advance and try new ideas and to stand up for principles in which he believes."

Two experts on municipal engineering problems praised the work of members of the engineering profession as public employees. Henry A. Barnes, *left,* director of traffic for the City of Baltimore, and Commissioner Samuel S. Baxter of the Philadelphia (Pa.) Water Department addressed a session of the Diamond Jubilee Spring Meeting of The American Society of Mechanical Engineers in the Lord Baltimore Hotel. The session was sponsored by the National Junior Committee of the Society.

[1] Westinghouse Electric Corp., Radio-Television Division, Metuchen, N. J.

[2] Assistant Engineer, Power Production Stations, Baltimore Gas and Electric Company, Baltimore, Md.

Part-Time Aid to Civic and Government Agencies

Mr. Barnes, in his presentation, dealt primarily with part-time aid the privately employed engineer can render civic-government agencies. He stated that he believed the engineer to be a little selfish in giving of his particular wares, especially from a community standpoint. "In general, the lawyer and the merchant are more generous in donating their time to community services. The engineer owes it to his community to do likewise. It is certainly true that he will not receive any money for his work but, undoubtedly, he will receive something much more valuable to his future. This, of course, would be experience. I can think of no field within the engineering profession where one may acquire a broader experience than in public service. However, while building up this backlog of experience, the young engineer may soon discover that while he may be making a great personal sacrifice in serving his community, his efforts may well prove a rather thankless task."

Mr. Barnes related several personal experiences indicating that one of the qualities that the engineer in public service must develop is the ability to ignore criticism leveled by those unfamiliar with all facets of the problems at hand. This point was made in an effort to reduce the disillusionment that might be felt by engineers who believe that people would readily acclaim their willingness to serve their community free of charge. Human nature being what it is, such would not be found to be the case.

"In fact," he went on, "the only remuneration that an engineer receives as a free adviser to his community lies in the satisfaction of knowing that he is doing everything he can within his field of experience and education to do a better job for his brother citizens." It was suggested that if the civic-minded engineer has a "thin skin," if his feelings are easily hurt, or if he expects recognition and credit for serving his community, he may be better off not donating his time for such services. If, however, the engineer feels that he wants the experience, that he enjoys the opportunity to deal with all kinds of problems in the broad sense that they are presented to governmental agencies, and that in spite of criticism he is going to do his best, then he can be a valuable asset to his community. In this manner the engineer performs tasks that, in many cases, could not be completed due to lack of funds. In fact, often it is only through the unselfish participation of qualified professional people that important civic improvements can be made.

At this point, it was emphasized by reference to personal experience that it is quite possible for the value of the engineer's efforts to be completely lost in a maze of advisory councils, governing boards, and the like. Mr. Barnes indicated that the greatest good can be accomplished by men of the engineering profession if they make use of their strength in numbers. They can band together as a group of qualified professional people and, as such, can bring tremendous pressure to bear on their municipal government. In this manner, career municipal engineers receive the proper backing and the authority with which to fulfill their mission.

"Too often the engineer sits back and says he would like to serve his community, but he hasn't been asked." In answer to this, it was pointed out that the engineer is certainly well educated and technically trained, and with a minimum of effort he can find fields of endeavor where he, as an engineer, can work a tremendous benefit to his community. He doesn't need to be asked. Certainly, if enough pressure is brought to bear behind carefully thought-out projects, it would not be long before the engineer's attention is not just tolerated, but sought after.

. . . Chairman's Corner[3]

For those who missed the Baltimore Spring meeting may I say that I hope you will not by-pass the Boston and Chicago meetings. Besides some excellent technical sessions there were many extracurricular affairs which I am sure that you would have enjoyed. It is sometimes necessary for you to scrutinize the program pretty carefully to find these nuggets of gold but it's worth while. For instance, there was a tea dance on Monday starting at about 5 p.m. that would have made any engineer forget his slide rule. And on Tuesday night after the banquet there was a dance for ASME members which I am sure that you would have enjoyed. I mention these social events for the benefit of those of you who get the idea that National meetings are a series of endless technical sessions.

While I'm on the subject I might mention that the Boston meeting coming up in June will provide an excellent excuse for you foreigners (people living outside New England) to visit New England at the prettiest time of the year. Inexpensive accommodations have been arranged in co-operation with M.I.T. If you want any additional information on the accommodations, write Duke Silvestrini in care of the Junior Committee. Or, if you prefer, you are welcome to contact me through Society headquarters.

Those attending the Junior Committee's session at Baltimore were almost unanimous in their belief that the engineer must take a greater part in civic affairs, because of the engineer's impact on our everyday living.

[3] Charles T. Miller, Chairman of National Junior Committee.

ASME Calendar of Coming Events

June 5–10
ASME Oil and Gas Power Conference, Hotel Statler, Washington, D. C.
(Final date for submitting papers was Feb. 1, 1955)

June 15–17
ASME and The Institution of Mechanical Engineers, London, England, Joint Conference on Combustion, Massachusetts Institute of Technology, Cambridge, Mass.
(Final date for submitting invited papers was Nov. 1, 1954)

June 16–18
ASME Applied Mechanics Conference, Rensselaer Polytechnic Institute, Troy, N. Y.
(Final date for submitting papers was Feb. 1, 1955)

June 19–23
Diamond Jubilee Semi-Annual Meeting, Hotel Statler, Boston, Mass.
(Final date for submitting papers was Feb. 1, 1955)

June 20–24
ASME Boiler and Pressure Vessel Committee Out-of-Town Meeting held jointly with the National Board of Boiler and Pressure Vessel Inspectors, St. Francis Hotel, San Francisco, Calif.

Sept. 12–14
West Coast Committee of the ASME Applied Mechanics Division, 1955 Western Conference on Applied Mechanics, U. S. Naval Post-Graduate School, Monterey, Calif.
(Final date for submitting papers was May 1, 1955)

Sept. 12–16
ASME Instruments and Regulators Division and Instrument Society of America Exhibit and Joint Conference, Los Angeles, Calif.
(Final date for submitting papers was May 1, 1955)

Sept. 25–28
ASME Petroleum-Mechanical Engineering Conference, Roosevelt Hotel, New Orleans, La.
(Final date for submitting papers was May 1, 1955)

Oct. 10–12
ASME-ASLE Second Lubrication Conference, Antlers Hotel, Indianapolis, Ind.
(Final date for submitting papers was June 1, 1955)

Oct. 19–20
ASME-AIME Joint Fuels Conference, Neil House, Columbus, Ohio
(Final date for submitting papers was June 1, 1955)

Nov. 13–18
Diamond Jubilee Annual Meeting, Hotel Congress, Chicago, Ill.
(Final date for submitting papers—July 1, 1955)

Nov. 14–18
Exposition of Power and Mechanical Engineering, as part of ASME 75th Anniversary Annual Meeting, Coliseum, Chicago, Ill.

Actions of the ASME Executive Committee

At a Meeting in Baltimore, Md., April 18, 1955

The Executive Committee of the Council met in two sessions on April 18, 1955, in the Lord Baltimore Hotel, Baltimore, Md., coincident with the ASME Spring Meeting. David W. R. Morgan, chairman, presided. In addition to Mr. Morgan, the following were present at both sessions: Thompson Chandler and A. C. Pasini of the Executive Committee; E. G. Bailey, F. S. Blackall, jr., H. V. Coes, and E. W. O'Brien, past-presidents; W. H. Byrne and W. G. McLean, vice-presidents; H. C. R. Carlson and R. L. Goetzenberger, directors; C. E. Davies, secretary, and Ernest Hartford, consultant. The following were present at the morning session only: D. Robert Yarnall, past-president; R. B. Lea, director; Lewis F. Lyne, Jr., guest; and T. A. Marshall, Jr., assistant secretary.

Mechanical-Engineering Education

Recently the Committee on Society Policy has devoted time to the part ASME should play in strengthening the pattern of formal education in mechanical engineering. The Committee submitted a formal statement and recommendations for consideration, which read in part as follows:

"This Committee believes strongly that the improvement of the education of mechanical engineers is one of the most critical problems facing our profession and should be attacked aggressively. The conclusion is the result of discussion over several months. The Committee notes confusion in some educational circles as between education of engineers and education of technicians. The accrediting process should take this into account and the accrediting agencies be governed accordingly.

"The present Society policies on education are stated in the Constitution and the By-Laws.

"The Constitution states one Society object as 'to foster engineering education.'

"The By-Laws provide that the Society (1) shall co-operate 'with educational institutions in the maintenance of high standards of engineering education' and (2) shall foster 'among engineering students the study of the philosophy and history, tradition and achievement, duties, and social functions of the engineering profession.'

"The By-Laws also stipulate that 'the Education Committee, under the direction of the Board on Education and Professional Status, shall supervise the work of the Society in relation to education of engineers at all levels and related matters.'

"The Education Committee has made some progress but should be encouraged to go farther.

"The provisions in the By-Laws quoted above are passive; they should be stated more aggressively. They should direct that the Society should 'take leadership' rather than merely 'co-operate.'"

The Executive Committee of the Council approved the recommendations of the Committee on Society Policy as follows:

1 The Education Committee (should) be encouraged to assume aggressive leadership toward improving the standards of education within the field of mechanical engineering in educational institutions and in training courses in industry, and submit reports and recommendations toward those ends through the Board on Education and Professional Status for Council review.

2 The Education Committee and the Constitution and By-Laws Committee (should) submit modifications in the By-Laws to describe an aggressive approach to the problem.

Sections

Establishment of the North Alabama Subsection of the Birmingham Section was authorized. The following counties are included: Lauderdale, Colbert, Lawrence, Limestone, Morgan, Madison, and Marshall.

Formation of the Central Savannah River Area Section was authorized Nov. 28–29, 1954. The Executive Committee approved the inclusion of the following counties in this Section: Wilkes, Lincoln, Taliaferro, Hancock in Georgia (from Atlanta Section), McDuffie, Warren, Columbia, Glascock, Washington, Jefferson, Richmond, Burke, Jenkens, Emanuel, Johnson in Georgia (from Savannah Section), McCormick, Edgefield, Aiken, Barnwell, Bamberg, Orangeburg, Calhoun, Lexington, Richland, Clarendon, Sumter, Lee, Florence, Williamsburg (from Greenville Section).

Machine Design Division

Establishment of a custodian fund for the Machine Design Division was authorized in accord with the policy adopted by the Council for such funds.

Certificates of Award

Certificates of Award were granted to the following retiring chairmen of Sections: B. W. Strachan, Fort Wayne; John E. Corr, Schenectady; and Charles W. Hathaway, West Virginia.

New Engineering Societies Building

Reports from the Committee of Five Presidents consisting of a majority report signed by L. F. Reinartz, L. K. Sillcox, E. B. Robertson, and C.G. Kirkbride, and a minority report signed by D. V. Terrell were transmitted to the Council under date of April 14, by L. K. Sillcox, ASME representative. Some two hours of discussion were devoted to this after which the Executive Committee of Council voted to refer the reports to the Council for consideration at its meeting in Boston, Mass., June 19–20, 1955. Any subsequent information is to be sent to the Council for review prior to the meeting.

The Secretary reported the Board of the American Institute of Mining and Metallurgical Engineers, at a meeting in New York, N. Y., on April 13, 1955, voted to defer action until the meeting of the Board on June 15, 1955. He reported also that the Board of Directors of the American Institute of Electrical Engineers on April 13, in St. Petersburg, Fla., voted "to accept and approve the majority report of the Committee of Five Presidents and recommend similar action to the four other societies."

The Secretary reported further that communications had been received from (1) Richard K. Mellon and Gwilym Price, both of Pittsburgh, and (2) from Mayor Robert F. Wagner, City of New York, Governor Averell Harriman, State of New York, Honorable Herbert Hoover, Special Committee of the Department of Commerce and Public Events, City of New York, and Jacob K. Javits, Attorney General, State of New York.

Appointments

The following appointments on committees and joint activities were approved:

A. W. Rankin to Research Committee on High-Temperature Steam Generation;

W. A. Crandall, Power Test Codes Committee on Determining Size of Small Particulate Matter;

R. W. Andrews, Jr., to ASA Sectional Committee on Safety Code for the Prevention of Dust Explosions, Z-12;

C. W. Wheatley, E. O. Bergman, alternate, to ASA Sectional Committee on Safety Code for Electric and Gas Welding and Cutting Operations, Z-49;

E. L. Robinson, reappointment, four-year term, to Engineering Foundation; and

C. G. Kirkbride, to Bureau of Standards, Technical Advisory Committees.

Presidential Appointments

The following appointments of presidential representatives were approved:

Edwin L. Pace to Inauguration of President Arthur B. Bronwell, Worcester Polytechnic Institute, April 30, 1955;

C. H. Shumaker to Inauguration of President Willis M. Tate, Southern Methodist University, Dallas, Texas, May 5;

Newton N. Sacks to Inauguration of President Harold P. Rodes, Bradley University, May 6.

Engineering Societies Personnel Service, Inc.

These items are from information furnished by the Engineering Societies Personnel Service, Inc., in co-operation with the national societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to all engineers, members, or nonmembers and is operated on a nonprofit basis.

In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient nonprofit personnel service and are available upon request. This also applies to registrant members whose availability notices appear in these columns. Apply by letter, addressed to the key number indicated, and mail to the New York office.

When making application for a position include six cents in stamps for forwarding application to the employer and for returning when necessary. A weekly bulletin of engineering positions open is available at a subscription of $3.50 per quarter or $12 per annum for members, $4.50 per quarter for nonmembers, payable in advance.

New York	Chicago	Detroit	San Francisco
8 West 40th St.	84 East Randolph St.	100 Farnsworth Ave.	57 Post St.

Men Available[1]

Mechanical Engineer, registered, seeks top-flight staff opening in oil or related industry. Background in tankers; bulk storage and dispensing systems; product application and development; contract administration and military POL. Me-223.

Director Research Engineering, 48, PhD. applied mechanics, mechanical and civil engineer-

[1] All men listed hold some form of ASME membership.

ing; ten years' direction of product manufacturing research; eight years' industrial and structural engineering; automotive, aircraft, machinery, metals; business training. Me-224.

Consulting Engineer to take charge of plant engineering and construction for large owner. ME, PE, design, construction, operation, maintenance experience. Presently employed. Me-225.

Mechanical Engineer, registered, 30, BSME, M.I.T.; seven years' design experience with heavy-machinery manufacturer. Mathematical and analytical ability. Desires permanent position with progressive organization as design engineer or research engineer. Me-226.

Mechanical Engineer, 39, married, paper-converting experience; seven years of responsible supervision in design and engineering in aforementioned industry; eight years' automatic machine designing in varied fields. Desires supervisory position in engineering department. Me-227.

Mechanical Engineer, 27, married; BSME, registered (Pa.); six years' experience machine design, product development for large manufacturer; some supervisory duties. Desires position involving design, research, or development in Eastern Pa. or vicinity. Me-228.

Positions Available

Instructor or Assistant Professor, MSME, to teach heat subjects and normal mechanical-engineering laboratories. Should be active in technical and professional organizations. Salary and academic rank open. Position starts September, 1955. Midwest. W-1169.

Engineers. (*a*) District sales manager, preferably with experience in blowers, compressors, turbines, for Midwest area. Must have had at least 10 to 15 years' previous sales experience. $15,000–$20,000. (*b*) Marine engineer, to head up large marine department, which would include engineering and sales for blowers, compressors, and turbines. Salary open. East. W-1264.

Engineers. (*a*) Senior industrial engineer, standards, systems, procedures; graduate, 30–35; background in time study and related work, measurement techniques; development of standards on manual and machine-paced operations. Must have demonstrated ability in application of standards; experienced in other areas of systems and procedures. $8400–$9000. (*b*) Junior time-study engineers, graduate, one to three years' sound time-study and standards experience, preferably with large organization. To $5700. South. W-1280.

Instructors. (*a*) Associate professor, industrial engineering, capable of developing a new department. $5000–$5500, nine-month year. (*b*) Assistant professor, PhD, for teaching applied mechanics. $4800, nine-month year. New England. W-1316.

Plant-Maintenance Section Foreman, 25–30, graduate mechanical, two to three years' industrial experience; working knowledge of plant equipment, building, and grounds. Will be responsible for maintenance of plant building and grounds; maintenance and inspection of all plant fire-protection equipment and alarms. $6000–$7000. Central N. J. W-1351.

Mechanical or Chemical Engineer, not over 40, for production management, with experience as foreman, for a manufacturer of finished chemical specialties, auto polishes, truck fluids, hydraulic fluids, plastic coatings, etc. $7000–$10,000. N. J. W-1358.

Chief Engineer, 35–42, mechanical or electrical graduate, design, production, and administrative experience covering FHP motors, synchros, and controls. $12,000. New England. W-1374.

Mechanical Engineer, graduate, steam-plant experience, preferably in a central station utilizing pressures of 850 psi and temperatures of 900 deg. Housing provided. Salary open. Venezuela. F-1398.

Plant-Betterment Engineer, mechanical graduate, five to ten years' experience in operation and betterment of steam-electric plants for public utilities. Diesel experience helpful. Some travel. Knowledge of Spanish desirable. New York, N. Y. W-1409.

Engineers, under 30. (*a*) Research or test engineer, BS or MS in mechanical engineering, experience in testing, research, or instrumentation, to work in the fields of heat transfer, refrigeration, air conditioning, and air handling. (*b*) Industrial-relations trainee, graduate, industrial-management major. Will receive training in all phases of industrial relations, such as wage and salary administration, job evaluation, recruiting, personnel administration, communications, safety, insurance, medical, and labor relations. Should have summer or part-time experience in manufacturing plant. Midwest. W-1415.

Research and Development Director, 35–50, graduate, at least ten years' research, development, and product-engineering experience covering domestic appliances, heating, ventilating and air-conditioning units, controls, and accessories. $20,000–$30,000. Pa. W-1422.

Plant Engineers, 25–35, graduate mechanical or electrical, for compiling data for various projects, running tests, supervising equipment installations, preparing minor designs and layouts, conducting preliminary equipment requirements and investigations, and carrying through on projects, for paper company. Midwest. W-1430.

Engineers. (*a*) Chief engineer, graduate mechanical and electrical, experienced in refrigeration, for research and design; supervising all engineering and drafting on low-temperature refrigeration cabinets. $10,000–$12,000. (*b*) Project engineer, to assist chief engineer on complete projects in the development of environmental test chambers. $6500–$8000. Conn. W-1436.

Plant Superintendent, 35–45, graduate mechanical, industrial, or metallurgical engineer, at least ten years' experience with general jobbing shop of the boiler-shop type, where alloy and code construction was practiced. Experienced with alloys such as, stainless steel, monel, nickel, copper, hastelloy, etc., very desirable. Familiarity with the application of power tooling for shaping and forming operations, slab work, machine-shop practice, welding by metallic arc, submerged gas (heliarc and sigma), and unionmelt is required. $9000, plus other benefits. Calif. W-1438.

Engineers. (*a*) Assistant manager-production supervisor, 35–45, experienced in operation, maintenance, construction of public-utility generating plant. $10,000–$12,000. (*b*) Chief systems operator, to 45, to take charge of hour-by-hour operations, load dispatching, and scheduling. $8000–$10,000. Ohio. W-1457.

Administrative Engineer, for design and drafting department, early 30's, graduate mechanical, administrative experience, to oversee the drafting and designing operations, assign work, supervise men, both hourly and salaried, improve methods and systems, reorganize if necessary and streamline the whole operation, for process instrument manufacturer. About $9000, plus fringe benefits and profit sharing. Pa. W-1461.

Instrument Engineers, BS in mechanical, chemical, or electrical engineering, preferably mechanical, with courses in thermodynamics, electricity, and magnetism, and preferably heat transfer. Should have three years of instrumentation work in a petroleum refinery or four years of similar work in a liquid-process chemical plant. Will analyze process data for application of automatic controls, recording, and indicating alarm systems; develop and prepare instrument specification and data sheets; calculate for equipment sizing, orifices, control, and relief valves; design instrument piping, etc. $7200 and up. New York, N. Y. W-1467.

Assistant Professor, young, advanced degree in mechanical engineering, background to teach elementary and intermediate courses in thermodynamics, heat, and power; possibly internal-combustion engines and interested in doing research in related fields. Salary open, depending on qualifications. Midwest. W-1470.

Instructors to Associate Professors, young, to teach in the mechanical-engineering department. Ranks and salaries depend on qualifications. West. W-1471.

Maintenance Engineer, graduate mechanical, 30–40, for multibuilding plant which provides steam and power services, electricity, compressed air, etc. Must have some heavy experience in running a boiler plant. Will be responsible for maintenance men, carpenters, electricians, etc. Promotion to chief engineer in about one year. Salary open. New York metropolitan area. W-1482.

Research Engineers, under 40, mechanical graduate, to do applied research in thermodynamics, automotive engineering, instrumentation, kinematics and statics, machine design, strength of materials, and related fields. Location, Midwest. W-1492(*b*).

Production-Control Manager, 30–40, approximately five years' experience in machine shop, tools, and assembly for hardware manufacturer. $9000–$12,000. Ohio. W-1495.

Engineers. (*a*) Manager, research and development, 30–35, mechanical or chemical graduate, experienced in the low-temperature drying field; the ability to analyze and solve abstract problems for humidity-control equipment manufacturer. (*b*) Sales engineer, 30–40, graduate, experience in the low-temperature drying field or related sales experience, for work with manufacturer of humidity-control equipment. Salaries open. Midwest. W-1500.

Sales Engineers. (*a*) Sales engineer, BS in mechanical engineering, two years' experience in process-equipment design and installation, project planning, and knowledge of all trades. Work involves supervision of drafting and engineering and field installations of process equipment. $6000. (*b*) Sales engineer, BS in mechanical engineering, extensive experience in the aeronautical product-development field, preferably aircraft wheel and brake. Work involves 60 to 70 per cent of travel and contacts with major aeronautical manufacturers. $5700–$6600. (*c*) Sales correspondent, industrial products, 25–30, BS in chemical or mechanical engineering or chemistry. Some knowledge of the rubber industry and desire to work into sales engineering of industrial products. Salary open. Ohio. W-1503.

Designers and Draftsmen. (*a*) Designer, preferably with BS degree in mechanical engineering and four years' experience in drafting practice and machine design, at least two years on the design of minor mechanisms. Will prepare detail drawings from sketches, prepare bills of material and assembly drawings, prepare layouts of important subassemblies, etc. Should be familiar with metal stampings, plastic moldings, die castings and machine subassemblies, etc. $6444–$7080. (*b*) Draftsmen, two, one a graduate mechanical engineer. Will work under supervision of designer. Experience should be as above. $3828–$7080. Employer will pay placement fees. Ohio. W-1504.

Instructors and Assistant or Associate Professor, to teach engineering mechanics, strength of materials, or fluid mechanics. For instructors, recent graduates from an accredited engineering school; assistant or associate professor, advanced degree and some experience. Instructor, $3300–$3600, nine months; assistant or associate professor, $4500–$6000, nine months. South. W-1505.

Teaching Personnel for mechanical-engineering department. (*a*) Associate professor, doctor's degree, preferably with teaching, research, and industrial experience; must be interested in research. (*b*) Assistant professor, MS, with some industrial experience; interested in research. (*c*) Instructor, BSME, some teaching and/or industrial experience. Salaries dependent on experience and qualifications. South. W-1527.

Chief Process Engineer, mechanical, at least ten years' metal forming and processing. Should have forming, blanking, compound and progressive die design, and be familiar with metal-forming machines and auto feeders. Familiarity with rubber-molding equipment desirable. Will be responsible for establishing and revising mechanical processes and specifications of tools and equipment. Will work with chief industrial engineer on efficient layouts, standards, staff training, and supervision. Salary open. West Coast. D-2015.

Plant Engineer, prior experience in paper mill required. Should be qualified to take complete charge of engineering, maintenance, and power for paper mill. Salary open. Midwest. D-2016.

Director of Engineering, mechanical or agricultural-engineering graduate, at least five years' experience directing product development and engineering activities; knowledge of farm machinery or road equipment desirable. $14,000–$20,000. Ohio. C-2925.

Process Engineer, graduate chemical or mechanical, 30–35, at least three years' experience in processing work in process industries and equipment; knowledge of electronics desirable. Duties include taking physical process and putting it into a system that an analog computer can handle and then interpreting results for practical use for an oil refinery. $6000–$9000. Calumet District. C-2949.

Plant Engineer, 35–45, at least five years' experience in maintenance and operation of power plant, mechanical equipment, and kilns; knowledge of malting operations desirable. Work includes handling complete plant-engineering problems on above equipment, for malt manufacturer. $7500–$10,000. Employer will pay fee. Wis. C-2954.

Plant Manager, 35–45, at least five years' experience as plant manager in stamping, plating, and assembly work on stainless or/and cold-rolled steel; knowledge of job-shop operations. Will be in full charge of production personnel, maintenance, industrial engineering, planning, scheduling, and purchasing. $10,000–$15,000. Mich. C-2976.

(*ASME News continued on page 566*)

it's **boiler check-up** time!

HOW ARE YOUR BLOW-OFF VALVES?

Are they drop-tight? Rugged and dependable? Easy to maintain?

Just as important, do they have all the advantages and up-to-date improvements in materials and design of new YARWAY Blow-Off Valves?

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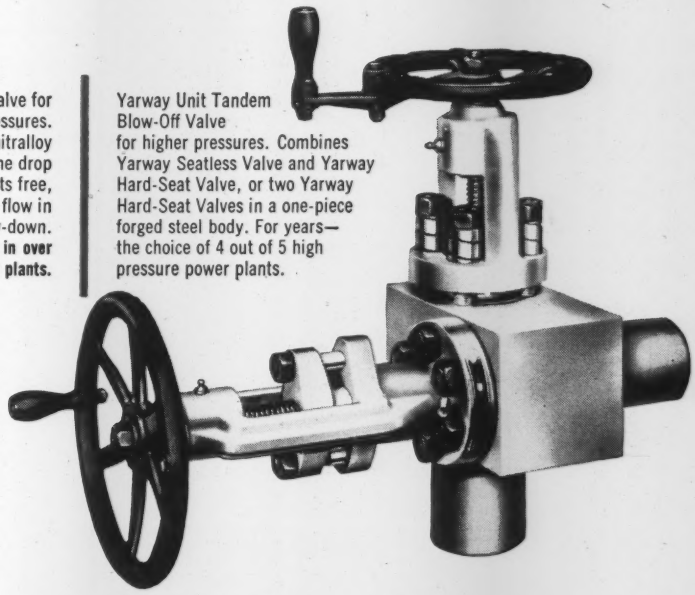
Yarway Seatless valve for low and medium pressures. Features balanced nitralloy plunger that seals line drop tight—yet permits free, unobstructed flow in blow-down. **Used in over 15,000 boiler plants.**



Yarway Unit Tandem Blow-Off Valve for higher pressures. Combines Yarway Seatless Valve and Yarway Hard-Seat Valve, or two Yarway Hard-Seat Valves in a one-piece forged steel body. For years—the choice of 4 out of 5 high pressure power plants.

YARWAY® blow-off valves

Candidates for Membership and Transfer in the ASME

The application of each of the candidates listed below is to be voted on after June 24, 1955, provided no objection thereto is made before that date and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the Secretary of The American Society of Mechanical Engineers immediately.

New Applications

For Member, Associate Member, or Affiliate

ABRAMSON, ROBERT Y., Paterson, N. J.
ALEXANDER, RAYMOND W., Walnut Creek, Calif.
ALLEN, CHARLES S., JR., Pittsburgh, Pa.
ALSOP, HUBERT A. F., Montgomery, Minn.
ALT, WILLIAM G., Schenectady, N. Y.
ANDREW, THOMAS A., Dallas, Texas
ARMENI, ROCCO, Mount Vernon, N. Y.
ARSON, SAMUEL L., Los Angeles, Calif.
AUBURN, BASIL J., Pittsburgh, Pa.
BALDNER, PAUL O., Long Beach, Calif.
BANFIELD, HARRY M., Portland, Ore.
BARKHUFF, EARL D., Poughkeepsie, N. Y.
BARNARD, THEODORE P., Keene, N. H.
BELL, JAMES F., Baltimore, Md.
BENJAMIN, HERBERT S., JR., Ft. Walton Beach, Fla.
BINGHAM, REIL D., W. Los Angeles, Calif.
BOGLE, HUGH A., Wilmington, Del.
BRENNER, ROBERT, Los Angeles, Calif.
CARR, DOUGLAS B., Cleveland, Ohio
CARTER, THOMAS J., Mexico, D. F., Mex.
CHAMBERS, JOHN A., Savannah, Ga.
CHANCE, HENRY M., 2ND, Philadelphia, Pa.
CHIALVA, DOMENICO, Turin, Italy
CICHELLI, MARIO T., Wilmington, Del.
CLUTE, ROGER H., Edmonton, Albt., Can.
COCHRAN, JAMES C., Chevy Chase, Md.
DAHL, ANDREW I., Schenectady, N. Y.
DALEY, JOHN C., Normal, Ill.
DAVIES, KENNETH W., Phoenix, Ariz.
DECRAENE, EDMOND P., Westchester, Ill.
DEL BUONO, AMERIGO J., New York, N. Y.
DITTMAN, GERALD C., Chicago, Ill.
DOBEK, JOSEPH K., Elmhurst, Ill.
DOUGLAS, CLEON L., Warren, Pa.
DOYLE, CHARLES M., Ft. Wayne, Ind.
ENGEL, RICHARD H., Homewood, Ill.
ENGLET, DAVID C., Dallas, Texas
FOUR, ERNEST E., Kew Gardens, L. I., N. Y.
FOX, MERRILL J., Chicago, Ill.
GABRIELIDES, ALEXANDER P., Athens, Greece
GARCIA, PRESTY E., Los Angeles, Calif.
GHAHREMANI-G, FARHAD, Detroit, Mich.
GLASER, RONALD A., Chicago, Ill.
GOMEZ-OJEDA, JOSE, Mexico, D. F., Mex.
HAFF, ARTHUR D., Quincy, Mass.
HEALY, EDWARD J., Bryn Mawr, Pa.
HEDAYA, MAURICE, Brooklyn, N. Y.
HINDE, EDWARD J., Orinda, Calif.
HOMER, CHARLES E., East Chicago, Ind.
HORAN, RAYMOND E., JR., El Cerrito, Calif.
HUBBARD, STEPHEN R., Compton, Calif.
IRONS, WILLIAM F., Pittsburgh, Pa.
ISHIMARU, KENZO, Campbell, Calif.
JACKET, HOWARD S., Pittsburgh, Pa.
JACKSON, LESTER G., Toronto, Ont., Can.
JEFFREY, GILBERT, Southampton, Pa.
JOHNSON, GORDON L., Monroe, Mich.
JONES, NORMAN S., Chicago, Ill.
KIPP, DAVID J., Pasadena, Calif.
KRAUSS, GEORGE V., Schenectady, N. Y.
KROCINSKI, VINCENT, JR., Stratford, Conn.
KRUEGER, GEORGE A., Chicago, Ill.
LANGER, LEON I., Bellerose, N. Y.
LAWRENCE, JOHN M., Calgary, Albt., Can.
LEADER, CHARLES C., Schenectady, N. Y.
LEGETT, BOB H., Lake Jackson, Texas
LEWIS, CARL B., Erie, Pa.
MACAULAY, ROBERT W., Scotia, N. Y.
MADISON, EARL L., JR., Pittsburgh, Pa.
MANKE, ERWIN E., Honolulu, T. H.
MASON, JOHN F., JR., New York, N. Y.
MCCAW, ROBERT K., Red Bank, N. J.
MCNAMARA, ROBERT E., Bellflower, Calif.
MEIBUHR, GEORGE C., Mentor, Ohio
MEINZER, ROY C., Kennett Square, Pa.
MENK, ELRAY W., Chicago, Ill.
MEYER, ROBERT A., Clarksburg, W. Va.
MIDDLEWOOD, ROBERT W., Marietta, Ga.
MITTENBERGS, ALEXANDER A., Lancaster, Pa.
MORRIS, HARRY E., New York, N. Y.
MYERS, CHARLES H., Pittsburgh, Pa.
NELSON, LUTHER G., Pensacola, Fla.
NELSON, WALTER A., Scotia, N. Y.
OHLGREN, HAROLD A., Ann Arbor, Mich.
PARDEN, ROBERT J., Santa Clara, Calif.
PARRISH, EARL M., Pittsburgh, Pa.
PAVEK, WILLIAM T., Berwyn, Ill.
PICHARDO-P, CARLOS, Mexico, D. F., Mex.
PIEROTTI, RAYMOND F., Albuquerque, N. Mex.
PILARCZYK, KAROL, Cleveland, Ohio
PULO, EDWARD J., Chicago, Ill.
RAU, ARTHUR H., Schenectady, N. Y.
RECK, JOHN H., St. Louis, Mo.
REICHERT, DAVID I., Norwalk, Calif.
REIZENSTEIN, MILTON, Baltimore, Md.
REYNOLDS, JOHN H., JR., Fitchburg, Mass.
RHODES, MAXWELL C., St. Louis, Mo.
RIOPELLE, EARL F., Grosse Pointe, Mich.
ROARK, RAYMOND J., Madison, Wis.
ROMBOUGH, STUART T., Schenectady, N. Y.
RONALD, WILLIAM R., St. Louis, Mo.
ROOSE, LELAND N., Seattle, Wash.
ROSENBERG, GEORGE E., Wellsville, N. Y.
ROSS, BERTRAM, Bronx, N. Y.
ROSS, PHILIP N., Pittsburgh, Pa.
RUBIN, FRANK L., Wynnewood, Pa.
RUGG, GORDON S., Rochester, N. Y.
RYAN, WILLIAM F., Salina, Kan.
SAHAY, KUMAR R. N., Springfield, Ohio
SCHREIBER, STANLEY, Woodside, N. Y.
SHEALS, VINCENT A., Schenectady, N. Y.
SHINER, CHARLES A., Hollywood, Calif.
SIEGEL, ELHARDT M., Pikesville, Md.
SMITH, ROBERT H., Schenectady, N. Y.
STARKEY, NEAL E., Schenectady, N. Y.
STEWART, ROBERT, Billericay, Essex, England
STRANG, CHARLES H., Fitchburg, Mass.
SWATMAN, IVAN M., San Diego, Calif.
TAYLOR, FRANK C., Corpus Christi, Texas
THOMAS, ROY W., Amarillo, Texas
TORRE, SALVATORE H., Paramus, N. J.
TRINGALI, RICHARD C., Chicago, Ill.
WALLACE, EUGENE J., Lanikai, T. H.
WALTON, CHARLES F., Cleveland, Ohio
WARD, DAVID A., North Augusta, S. C.
WARREN, JOHN, Baltimore, Md.
WAWZONEK, JOSEPH, Central Falls, R. I.
WEISS, ALBERT, Pittsburgh, Pa.
WHITE, CHARLES C., Pensacola, Fla.
WHITE, VERNON R., Schenectady, N. Y.
WHITEHOUSE, GEORGE M., East Haven, Conn.
WILLIAMS, ALBERT J., JR., Philadelphia, Pa.
WINKLEPLECK, ROY G., Wellsville, N. Y.

Change in Grading

Transfers to Member or Affiliate

ALLEN, WILLIAM F., JR., Boston, Mass.
ANDERSON, HARLAN J., Chicago, Ill.
BAILEY, CHARLES H., Berkeley, Calif.
BOND, WILLIAM H., La Grange, Ill.
ESPESETH, EVAN S., Sacramento, Calif.
GARMEZY, ROBERT H., Jamestown, N. Y.
HALL, CARL W., East Lansing, Mich.
HOLLAWAY, RAYMOND L., JR., New Philadelphia, Ohio
IVANOVIC, PETER, Wilmerding, Pa.
KETTLES, THOMAS L., Yonkers, N. Y.
LAMBERT, RICHARD P., Allen Park, Mich.
LAWSON, HARRY M., Philadelphia, Pa.
PETERSON, ROY R., Sterling, Va.
RANSDELL, CLIFFORD H., College Station, Texas
ROSSI, MARINO A., Trenton, N. J.

Transfers from Student Member to Associate Member 225

Obituaries . . .

Malcolm Bacon (1888–1955), assistant chief appraisal engineer, Oil Division, Los Angeles County Assessor's Office, Los Angeles, Calif., died Feb. 2, 1955. Born, Niles, Mich., July 14, 1888. Education, ME, Lewis Institute, 1911. Mem. ASME, 1933. Survived by wife, Helen; two daughters, Mrs. Shannon Pedlow and Mrs. John Penn; two brothers, John L., former Mayor of San Diego, and Harold; and three grandchildren.

William Vinson Bibb (1926–1955), captain, USAF, Clark AFB, Philippine Islands, was killed in a military aircraft accident over Formosa, Feb. 5, 1955. Born, Ottumwa, Iowa, May 6, 1926. Parents, William A. and Lorene (Vinson) Bibb. Education, BS(ME), Iowa State College, 1949; graduate work in engineering administration, Illinois Institute of Technology, 1950–1951, University of Illinois, 1952; social studies, Rollins College, 1951. Married Charlotte Coleman, 1953. Assoc. Mem. ASME, 1953. He held membership in Tau Beta Pi and Pi Tau Sigma. He was presented honorary membership and wings of the Royal Thai Air Force at a state dinner held in Bangkok, June 25, 1954. Survived by wife; two children, John and Sharon Ellen; and his mother.

Harry Bainbridge Boies (1894–1955), chief industrial engineer, Athey Products Corp., Chicago, Ill., died in February, 1955. Born, Buffalo, N. Y., Nov. 14, 1894. Education, ME, Cornell University, 1916. Jun. ASME, 1918; Assoc-Mem. ASME, 1929; Mem. ASME, 1935. He held U. S. Patents pertaining to auto air pumps. Survived by wife.

William Edward Bowler (1892–1955), owner, W. E. Bowler, manufacturers' representative, Philadelphia, Pa., died Feb. 22, 1955. Born, Spencer, Mass., July 17, 1892. Education, BS(EE), University of Maine, 1915. Mem. ASME, 1948. Survived by wife, Marie Z. Bowler.

Robert Stanley Brown (1867–1955), secretary of the New Britain (Conn.) Machine Co. for 54 years until his retirement in 1943, died Feb. 21, 1955. Born, Stonington, Conn., July 8, 1867. Parents, Thomas F. and Mary (Harrison) Brown. Education, common school; private tutoring. As a boy of 13, in 1880, he got a job at the Stanley Works in New Britain as an office boy and shipping-room clerk. In 1887 he left the Stanley firm and became the first employee of the newly organized J. T. Case Engine Co. Within a few weeks he was named secretary of the new firm. He retained the position after the company was reorganized as the New Britain Machine Co. in 1895 and held it until his retirement in 1943. He continued to serve as consultant and director until his death. He held several United States and foreign patents on wood and metalworking machine tools. Jun. ASME, 1891; Mem. ASME, 1904. Five years after the establishment of the New Britain General Hospital Mr. Brown was named clerk of its board of directors. He was elected a director in 1911 and secretary in 1915. He retired as director emeritus in 1951 after 48 years of service on the board. He was also a director of the New Britain Gas and Light Co. He was a past-president of the Hartford County Manufacturers Association; a patron of several art societies; and a trustee of the North Shore Association of Artists of East Gloucester, Mass. Survived by his wife, Grace (Wolcott) Brown; a son, Wolcott S. Brown, Berlin, Conn.; a daughter, Mrs. F. Warren Rees, Charlotte, N. C.; and four grandchildren.

John G. (Burmistroff) Burmist (1887–1955), president, Vibration Specialty Co., Philadelphia, Pa., died March 9, 1955. Born, Kashine Tver, Russia, 1887. Education, gymnasium; graduate, Institute of Technology, Petrograd, 1914. Assoc.-Mem. ASME, 1924; Mem. ASME, 1935. His specialized work included the balancing of rotating parts of machines, limit foundation vibration; and research work in problems of balance.

Thomas Cecil Cheasley (1889–1955), vice-president, Sinclair Coal Co., Kansas City, Mo., and prominent fuel and combustion engineer, died March 17, 1955, at his home in Fort Lauderdale, Fla. Born, London, England, Aug. 1, 1889. Parents, William J. and Frances H. (Stevens) Cheasley. Education, graduate, London Collegiate Institute, London, Canada; University of Illinois Extension Courses in engineering. Naturalized U. S. Citizen, Tulsa, Okla., Jan. 30, 1926. Married Lydia W. Dancy, 1910. Mem. ASME, 1939. He received the Fuels Division Award for his services from 1945 to 1949 and for serving as chairman in 1948. Actively engaged in the American coal industry and land reclamation activities, he was registered engineer, author of several technical papers, holder of a number of U. S. Patents pertaining to coal-treating boxes, locomotive combustion arch, water-cooled stoker hearth, and stove construction, and held membership in many professional societies. He was chairman of the Percy Nicholls Award Committee of ASME-AIME, 1954. He was a member of the Mechanical Advisory Committee of the Locomotive Development Committee of Bituminous Coal Research, Inc., as well as several others. In coal research he supervised electrocarbonization of coal experiments conducted near Hume, Mo., which resulted in the development and patenting of a method to burn coal underground and use the resulting gases commercially. He took active part in the U. S. Chamber of Commerce and local civic affairs. Survived by wife; two sons, T. Bruce, Mission, Kan., Richard Neil, Parkville, Mo.; and five grandchildren.

Harry Francis Coleman (1896–1955), contracting engineer, Grinnell Co., Inc., Providence, R. I., died March 11, 1955. His home was in New Orleans, La. Born, Oswego, N. Y., April 2, 1896. Parents, John B. and Sara T. Coleman. Education, BS(ME), Brown University, 1919. Married Georgette C. Schmitt, 1924. Jun. ASME, 1923; Assoc-Mem. ASME, 1925; Mem. ASME, 1935.

Thomas Edward Cranley (1901–1955), secretary, The Wirthlin-Mann Co., Cincinnati, Ohio, died Feb. 26, 1955. Born, Cincinnati, Ohio, Nov. 26, 1901. Education, graduate, Milwaukee Trade School. Mem. ASME, 1942. Survived by wife, Helen Sullivan Cranley; daughter, Sister Helen Thomas, stationed at Good Samaritan Hospital, Cincinnati, Ohio; and mother, Mrs. Julia McCan.

Edmund Burke Devoy (1890–1954), marine surveyor, Honolulu, T. H., died in November, 1954. Born, Eureka, Calif., Feb. 26, 1890. Education, public schools of Eureka. Assoc-

(*ASME News continued on page 568*)

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Mem. ASME, 1935. He held membership in Sugar Technologists of Hawaii. Survived by wife.

Joseph Edward Durham, Jr. (1882–1955), retired, vice-president, Bonney Forge & Tool Works, Allentown, Pa., died Jan. 15, 1955. He lived at Skew Farm, Zionville, Pa. Born, Williamsport, Pa., Aug. 23, 1882. Parents, Joseph E. and Nellie R. (Stranahan) Durham. Education, AB, Princeton University, 1906. Married, Hannah M. Young, 1913. Assoc. ASME, 1940. Survived by wife.

Aubrey J. Grindle (1889–1955), president, Grindle Corp., Harvey, Ill., died March 13, 1955. Born, Swayzee, Ind., July 11, 1889. Education, mechanical and electrical engineering, ICS, 1912. He held more than 25 U. S. Patents pertaining to coal, foundry, and steel-processing machinery. Mem. ASME, 1954.

Lewis Hobart Kenney (1875–1955), retired engineer, Philadelphia, Pa., died March 27, 1955. Born, East Milton, Mass., Nov. 17, 1875. Parents, Samuel B. and Kate E. Kenney. Education, BS, New Hampshire College, 1899; ME, 1906. Jun. ASME, 1904; Mem. ASME, 1911. He served the Society on the following committees: Constitution and By-Laws and Cutting Metals. Author of technical papers on cutting-metals test procedure.

Robert Moeller (1914–1955), mechanical engineer, Engineering and Design Section, David Taylor Model Basin, Washington, D. C., died Feb. 25, 1955. Born, Cleveland, Ohio, Jan. 16, 1914. Parents, Hans and Caroline Moeller. Education, BS, Case School of Applied Science, 1935; MS(ME), 1937. Jun. ASME, 1937; Mem. ASME, 1947. Survived by wife, Delphine Moeller.

Louis Spence Niper (1898–1954), owner, firm of Louis S. Niper, real estate, Clinton, Conn., died Dec. 17, 1954, at Northampton, Mass. Born, Brooklyn, N. Y., Nov. 7, 1898. Parents, Mr. and Mrs. William D. Niper. Education, graduate, Pratt School of Science and Technology, 1920. Married, Rosalie Barri, 1917; children, Lorraine, Rosalie, Joel, Louis. Jun. ASME, 1925.

Dwight Parker Robinson (1869–1955), retired, president, Dwight P. Robinson & Co., Inc., constructing and consulting engineers, New York, N. Y., died March 17, 1955, at his home in Pocasset, Mass. Born, Boston, Mass., May 1, 1869. Parents, Edgar and Susannah (Powell) Robinson. Education, AB, Harvard University, 1890; BS, Massachusetts Institute of Technology, 1892. Married Mary Elizabeth Stearns, 1897 (died 1907). Married 2nd, Mary Elizabeth Dahlgren, 1912. Organized his company in 1919 and engaged in engineering and construction work in the United States and abroad; in 1928 merged with three other organizations to form the United Engineers & Constructors, Inc. Mem. ASME, 1919. He was a Fellow of the American Institute of Electrical Engineers. Survived by two sons, Powell and Dwight P. Robinson, Jr.

Jagir Singh (1908–1954), owner, J. S. Grewal & Co., New Delhi, India, died Nov. 13, 1954. Born, Raipur, Distt: Ludhiana, India. Education, completed five-year course at Maclagan Engineering College, Lahore, India, 1930. He was a First-Class Competency Engineer under the Indian Boilers Act; license issued by Punjab Board of Examining Engineers, 1934. Jun. ASME, 1934; Mem. ASME, 1950.

John Tilley (1873–1955), mechanical and electrical engineer, Vermilya-Brown Co., Inc., New York, N. Y., died Jan. 27, 1955. Born, Watervliet, N. Y., Sept. 7, 1873. Parents, James and Mary (Littlefield) Tilley. Education, BS, Massachusetts Institute of Technology, 1896. Married Gertrude E. Brink, 1908; daughter, Gertrude L. Mem. ASME, 1914.

Alan Arthur Wood (1891–1955), president, Alan A. Wood, Inc., Philadelphia, Pa., died Jan. 29, 1955. Born, Philadelphia, Pa., Nov. 6, 1891. Parents, Richard H. and Ida (Townsend) Wood. Education, BS(ME), Brown University, 1911. Married Madeleine Evans, 1922. Author of numerous technical papers. Jun. ASME, 1914; Mem. ASME, 1926. Survived by wife; son David, Washington, D. C.; daughter, Mary.

Robert Ernest Wright (1893–1954), Reserve Training Officer, U. S. Navy, Pacific Reserve Fleet, U. S. Naval Shipyard, San Francisco, Calif., died Aug. 6, 1954, according to a notice received recently by the Society. Born, Richmond, Va., July 16, 1893. Parents, John T. and Lelia (Nelson) Wright. Education, graduate, Wilmerding School of Industrial Arts, San Francisco, Calif., 1911; special work, California Institute of Technology. Married May H. Roberts, 1930. Mem. ASME, 1930. He was active in civic affairs; served on City Planning Commission, Sierra Madre; past-president, Planning Congress of Los Angeles County. Author of reports and technical papers on lubricants, fuels, maintenance, and repair practices and techniques.

Keep Your ASME Records Up to Date

ASME Secretary's office in New York depends on a master membership file to maintain contact with individual members. This file is referred to dozens of times every day as a source of information important to the Society and to the members involved. All other Society records and files are kept up to date by incorporating in them changes made in the master file.

From the master file are made the lists of members registered in the Professional Divisions. Many Divisions issue newsletters, notices of meetings, and other materials of specific interest to persons registered in these Divisions. If you wish to receive such information, you should be registered in the Divisions (no more than three) in which you are interested. Your membership card bears key letters opposite your address which indicate the Divisions in which you are registered. Consult the form on this page for the meaning of the letters. If you wish to change the Divisions in which you are registered, please notify the Secretary's office.

It is important to you and to the Society to be sure that your latest mailing address, business connection, and Professional Divisions' enrollment are correct. Please check whether you wish mail sent to home or office address.

For your convenience a form for reporting this information is printed on this page. Please use it to keep the master file up to date.

ASME Master-File Information

(Not for use of student members)

Please print **Check mailing address**

Name..... (Last / First / Middle)

Home address..... (Street / City / Zone / State) ☐

Name of employer.....

Address of employer..... (Street / City / Zone / State) ☐

Product or service of company.....

Title of position held.....

Nature of work done.....

I am a subscriber to (please check)

Publication	*Address changes effective when received prior to:*
☐ Mechanical Engineering	10th of preceding month
☐ Transactions of the ASME	20th of preceding month
☐ *Journal of Applied Mechanics*	20th of preceding month
☐ *Applied Mechanics Reviews*	1st of preceding month

Please register me in three Professional Divisions as checked:

☐ A—Aviation	☐ J—Metals Engineering	☐ S—Power
☐ B—Applied Mechanics	☐ K—Heat Transfer	☐ T—Textile
☐ C—Management	☐ L—Process Industries	☐ V—Gas Turbine Power
☐ D—Materials Handling	☐ M—Production Engineering	☐ W—Wood Industries
☐ E—Oil and Gas Power	☐ N—Machine Design	☐ Y—Rubber and Plastics
☐ F—Fuels	☐ P—Petroleum	☐ Z—Instruments and Regulators
☐ G—Safety	☐ Q—Nuclear Engineering	
☐ H—Hydraulics	☐ R—Railroad	